REPORT # ESD/LM/99-1

GUIDELINES FOR RECLAMATION TO FOREST VEGETATION IN THE ATHABASCA OIL SANDS REGION

Alberta
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Land and Forest Service

Alberta
ENVIRONMENTAL PROTECTION
Land Reclamation Division

Syncrude
Securing Canada's Energy Future

SUNCOR
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Shell Canada Limited

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FOREST INDUSTRIES INC

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FOREST PRODUCTS LTD.

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Guidelines For Reclamation To Forest Vegetation In The Athabasca Oil Sands Region

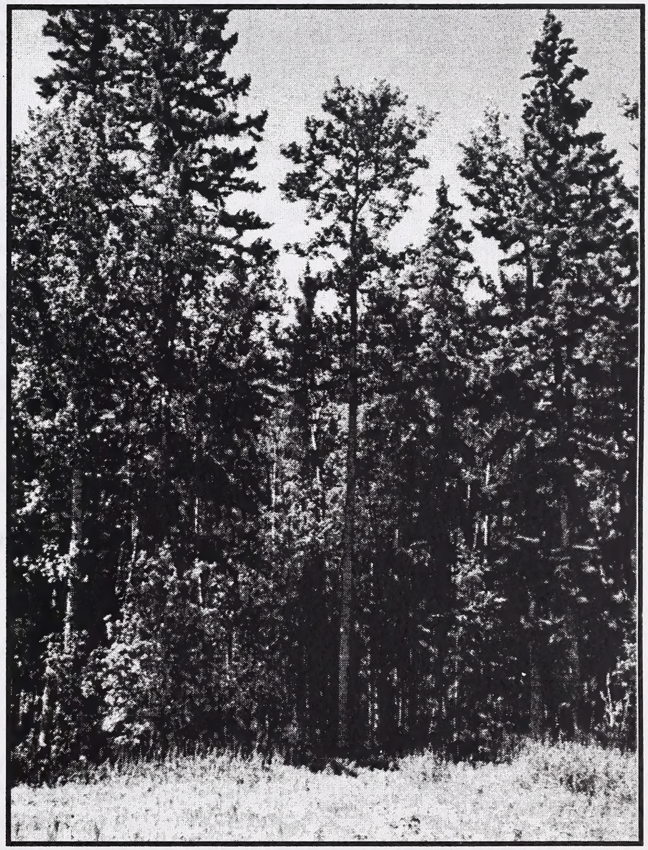

Photo: Kevin Gagne

Prepared By The Oil Sands
Vegetation Reclamation Committee

Fort McMurray, Alberta
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EXECUTIVE SUMMARY

The Oil Sands Vegetation Reclamation Committee was formed in November 1996 with the mandate to prepare guidelines on the establishment of forest vegetation (ecosystems) for reclaiming oil sands leases in northeastern Alberta. The Committee focussed on starter vegetation and design criteria for ecosystems that would support primarily commercial forests and secondarily would provide wildlife habitat. In addition, biodiversity was considered an important aspect of reclaimed ecosystems. The guidelines have been based on successful reclamation techniques, and research and monitoring information that were available for the oil sands region at the time of document preparation. As research and monitoring programs continue in the region, new data will be used to update and refine the suggested approaches and techniques every 5 years.

The guidelines are intended to be used by government and industry staff. They provide detailed information on what terrestrial vegetation (ecosystems) can be re-established to support commercial forests and wildlife habitat, how to establish the ecosystems through reclamation techniques, and how to monitor whether the reclamation approach has been successful. Information gaps that exist and assumptions that have been made have been documented.

The Committee designed a seven-step process to meet their mandate. The main conclusions are discussed below.

Step 1 – Identify Target Ecosites that can be Established on Reclaimed Landscapes

The first step was to identify which ecosites, of those that occur in the oil sands region, can be supported on reclaimed landscapes.

The ecosites that naturally occur in the oil sands region were identified based on the ecological classification system for northern Alberta produced by Beckingham and Archibald (1996) and are summarized in Section 3.1. The ecosites that can be re-established on reclaimed leases depend on the landscapes, drainage patterns and soils that can be re-established. The ecosites that are emphasized in this document are those that are most likely to develop on the range of landscape features (position, slope and aspect) and soil types that currently exist in reclaimed areas on the Syncrude Canada Ltd. (Syncrude) and Suncor Energy Inc. (Suncor) leases.

Step 2 – Identify Techniques to Establish Ecosites on Reclaimed Landscapes

Techniques that have been developed through research and monitoring by Syncrude and Suncor to reconstruct the landscape/drainage patterns and soils, and to initiate "starter vegetation" that should eventually succeed to the targeted ecosites on their oil sands leases were compiled. They are summarized in Section 3.2.

Step 3 – Identify Terrestrial Land Use Objectives for Reclaimed Landscapes

The Oil Sands Vegetation Reclamation Committee examined the design criteria for ecosystems and landscape components that would meet two land use objectives: the establishment of stands of commercial forest and the establishment of wildlife habitat.

Design criteria for other land uses that can be examined at a later date include recreation and traditional use. Ultimately, each oil sands lease will be designed to support several integrated land uses.

Step 4 – Identify the Design Criteria for Ecosystems and Landscape Patterns to Achieve the Selected Terrestrial Land Use Objectives

The fourth step in the process was to identify the design criteria required for the reclaimed landscape to support commercial forest and wildlife habitat. Design criteria included information on the preferred types of ecosites and preferred patterns of distribution of ecosites in the landscape. The design criteria for commercial forest are outlined in Sections 4.1 and 4.2. The design criteria to create habitat for ten species of wildlife are outlined in Sections 5.1.1 and 5.2, and Appendix J.

Step 5 – Integrate Design Criteria for All Land Use Objectives for Reclamation of Oil Sands Leases

It is intended that lease holders will use these guidelines to assist in designing their landscapes to achieve the required end land uses. Once the design criteria for each of the primary and associated land uses have been identified, the distribution pattern of the preferred ecosites for the primary land uses within the leases needs to be identified. Then the design criteria for the associated uses need to be integrated into the design criteria for the primary uses. This is an important planning exercise that should be completed by an operator of an oil sands development during the design of the closure plan. This step is not discussed further in this guideline manual.

Step 6 – Design Monitoring Programs to Verify that Land Use Objectives have been Successfully Met

The sixth step in the process was to design monitoring programs to determine if the land use objectives have been achieved. These have been outlined in Sections 6.1 and 6.2 of this document.

Recommendations for monitoring programs for the establishment of a commercial forest include:

- Confirmation that tree seedlings have been established (as benchmarked through compliance requirements under the Timber Management Regulations and Alberta Regeneration Survey Manual), and
- Confirmation that forest productivity has been re-established (as benchmarked through measurements of tree height, mean annual increment and site index, and soil capability).

Recommendations for monitoring the establishment of habitat capability for wildlife include:

- Measurement and modeling of biophysical characteristics of re-established ecosites and physical features of landscape components (fine filter approach), and/or
- Interpretation of biodiversity information on the plant community and landscape levels (coarse filter approach).

Recommendations for monitoring biodiversity on reclaimed landscapes includes the collection of information on the landscape, plant community and genetic levels of variation.

Step 7 – Recommend Research Programs to Address Information Gaps on Reclamation

Research programs to address information gaps identified in the reclamation information include:

- Vegetation productivity (site index) on reclaimed soils needs to be measured and compared to vegetation productivity on natural soils,
- The relationship between soil capability classes and vegetation productivity (site index) needs to be identified through monitoring programs,
- It is uncertain whether all plant species recommended as starter species can be propagated on reconstructed soils. Future propagation of additional plant species, such as those in Appendix H, needs to be studied,
- The survival and vitality of plant species moved through direct placement from various ecosystems to reclamation sites supporting different subsoils needs to be examined,
- The potential effects of elevated pH levels in reconstructed soils on plant growth are not known and need to be studied,
- The feasibility of using mineral soil through direct placement to develop upland ecosystems needs to be examined,

- The effectiveness of covering and reclaiming saline/sodic materials needs to be studied,
- The feasibility of continuing the use of exotic plant species in reclamation needs to be examined,
- Methods to measure biodiversity need to be developed,
- Draft seed zone maps for the oil sands area were developed with the intention of covering both woody and other vascular plants but may need to be further refined to determine their suitability for other vascular plants,
- The feasibility of re-establishing ecosystems on consolidated/composite tailings (CT) needs to be researched,
- The feasibility of applying sulphur to reduce soil pH and sodicity needs to be examined,
- Methods to enhance the establishment of native understorey species to achieve greater biodiversity than is possible through seeding/planting need to be developed,
- The biology and productivity of reclaimed soils should be examined. Mycorrhizae, nutrient cycling and sustainability of peat-mineral mix amendments to ensure that the "living" components of the soil system are functioning effectively and in balance should be the focus of the research,
- Seed sources for species that provide good timber/fibre production need to be improved,
- Essential ecosystem functions and plant species required to accomplish these functions need to be determined, and
- The ability to create ecosites d (low-bush cranberry) and e (dogwood) without adding clay is uncertain. The sustainability of the ecosites needs to be studied.

ACKNOWLEDGEMENTS

The Oil Sands Vegetation Reclamation Committee has been comprised of the following representatives:

• Earl Anderson	Syncrude Canada Ltd.
• Harry Archibald	Alberta Environmental Protection Land and Forest Service
• Bert Ciesielski	Alberta Environmental Protection Land and Forest Service
• Tom Coolen	Syncrude Canada Ltd.
• Garry Ehrentraut	Northland Forest Products Ltd.
• David Fox	Alberta Pacific Forest Industries
• Chris Hale	Alberta Environmental Protection Land and Forest Service
• Leonard Leskiw	Can-Ag Enterprises Ltd.
• Jeff Sansom	Alberta Environmental Protection Land Reclamation Division
• Judith Smith	Shell Canada Limited
• Steve Tuttle	Suncor Energy Inc.
• Carl Warner	AGRA Earth & Environmental Limited

Other technical information was supplied by:

• Narinder Dhir	Alberta Environmental Protection Land and Forest Service
• Grant Klappstein	Alberta Environmental Protection Land and Forest Service
• Calvin Duane	AGRA Earth & Environmental Limited

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1. INTRODUCTION

The Oil Sands Vegetation Reclamation Committee (herein referred to as the Committee) was formed in November 1996 to prepare guidelines on the establishment of forest vegetation (ecosystems) with emphasis on providing appropriate starter vegetation to use for reclaiming surface mineable oil sands leases in northeastern Alberta (Figure 1.1). Vegetation in wetlands, commercial forest and environmental reserves is governed by the Alberta Forest Act and Government policy documents such as the Regeneration Survey Manual, Timber Harvesting Ground Rules, Recommended Native Grasses and Legumes for Revegetating Disturbed Lands in the Green Area, Forest Conservation Strategy and/or the Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan.

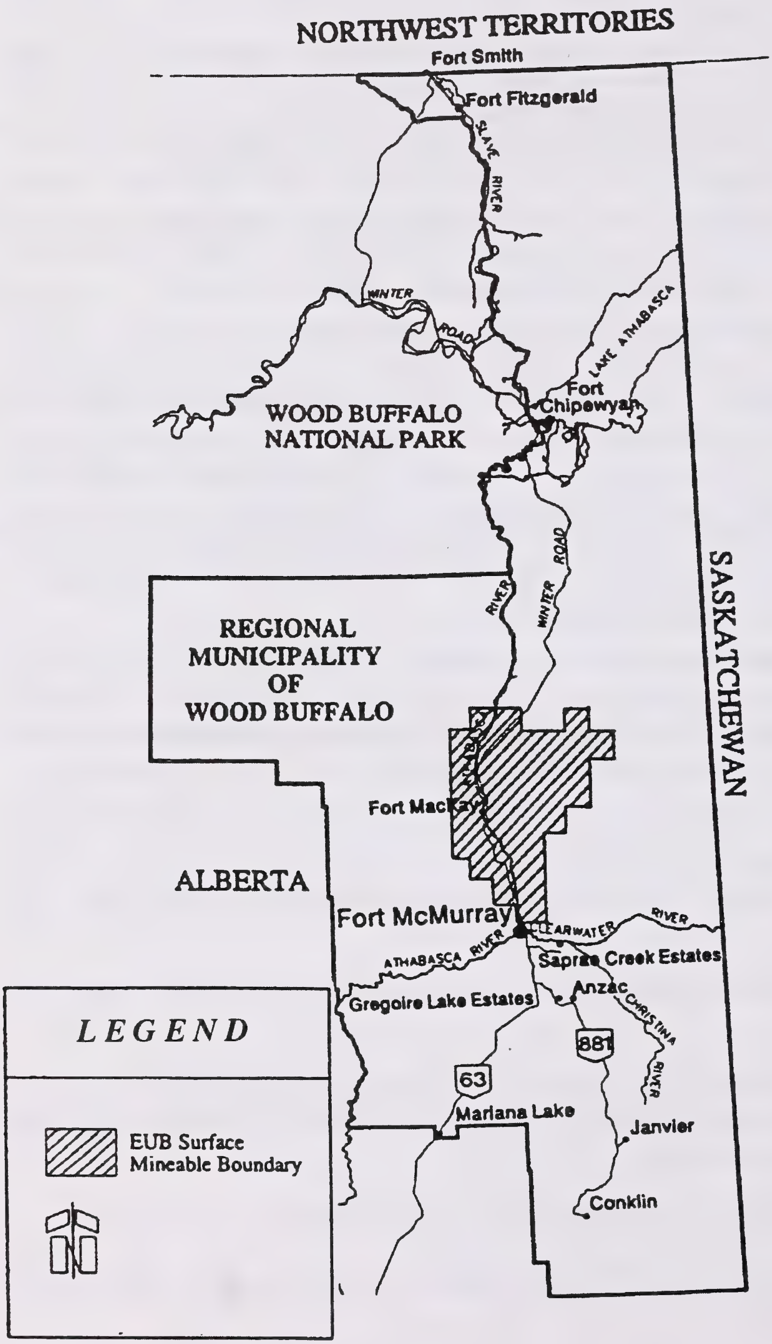
An integrated approach to oil sands lease development involves three reclamation steps: facility design and layout, land use planning, and developing reclamation strategies and techniques. The objective of reclamation is to establish sustainable ecosystems that replace equivalent levels of predisturbance land use capabilities. The ecosystems that will become established will be determined by the design of the reclaimed landscape, the types of reconstructed soils, revegetation techniques, and natural processes over time. In most instances, all ecosystems re-established after mining will contribute to more than one land use. However, some ecosystems and their landscape patterns may be designed to enhance their suitability for one particular land use.

Stakeholders in northeastern Alberta have requested that the oil sands leases be reclaimed to some of the predisturbance ecosystems and land uses. For example, commercial timber harvesting companies have requested that an equivalent predisturbance landbase and productivity of white spruce, jack pine, mixedwood and aspen ecosystems be returned. Aboriginal groups, the public, other industries and Government have asked that re-established ecosystems produce equivalent levels of productivity for wildlife habitat. Other important predisturbance values and land uses that could be re-established include watershed functions, wetlands, sources of traditional foods and medicinal plants, and recreation.

The guidelines in this document have been designed to provide its users with information on:

- Terrestrial ecosystems comprised of forest vegetation that can be supported by reclaimed landscapes and soils (i.e., nutrient and moisture regimes) established on oil sands leases (Section 3.1),
- Practical techniques to re-establish forest ecosites (Section 3.2),
- Information gaps on reclamation and research recommendations (Sections 3.4 and 5.3.3),

Figure 1.1 Athabasca Oil Sands Surface Mineable Boundary



- Terrestrial ecosystems and landscape patterns that support two land use objectives for the oil sands leases region, i.e., commercial forest (Section 4.0) and wildlife habitat (Section 5.0),

- Practical approaches to monitor the re-establishment of ecosystems and to verify that the selected land use objectives have been met (Section 6.0), and

- Natural landscapes, soils, vegetation and ecosystems that occur in the oil sands region (Appendices A and B).

To date, several plant communities have been developed ranging from grassland complexes to a variety of forest cover types. The guidelines will help define and streamline the reclamation planning process.

The guidelines have been based on current reclamation objectives, successful reclamation techniques, and research and monitoring information available for the oil sands region at the time of document preparation. As research and monitoring programs continue in the region, new data will be used to update and refine the suggested approaches and techniques (Section 7.0).

A glossary of terms used in this document is included in Section 8.

1.1 MANDATE AND OBJECTIVES OF THE COMMITTEE

The Committee was formed following a November 26, 1996 workshop sponsored by the Alberta Land and Forest Service, and involving Syncrude Canada Ltd. (Syncrude), Suncor Energy Inc. (Suncor), and other industry representatives. The Committee was comprised of representatives from the oil sands and forest industries, government and consultants. These representatives provided a broad array of expertise on policy and regulatory requirements, reclamation approaches and techniques, soils, vegetation, forestry and wildlife for northeastern Alberta. The Committee's mandate was to prepare recommendations that will provide guidance on the establishment of appropriate terrestrial vegetation (ecosystems) to meet two land use objectives in the oil sands region: commercial forest and wildlife habitat.

The objectives of the Committee were to identify:

- Approaches to oil sands lease reclamation that will meet regulatory guidelines and revegetation requirements,

- The forest ecosites that can be established on oil sands leases,

- The existing reclamation methods available to develop these ecosystems,

- The principles of landscape and ecosystem design to meet the land use objectives of commercial forest and wildlife habitat,

- The biodiversity objectives that should be considered,
- How the success of reclamation should be monitored, and
- The additional research that is required to address present information gaps and future improvements in reclamation research.

The approach and process used by the Committee to address these objectives and develop the guidelines are outlined in Section 2.0.

Recommendations of the Committee will be forwarded to the participating industry and government divisions. The recommendations are consistent with Provincial Acts, Regulations, Policy Statements, Manuals and Approvals that are applicable to vegetation, and reclamation of oil sands leases (Appendix C). For example, the "Recommended Native Grasses and Legumes for Revegetating Disturbed Lands in the Green Area" (Alberta Environmental Protection 1996b) states that vegetation used for ecosystem development needs to be native to eco-subregions. The ecosystems developed need to be sustainable and provide a sustainable range of uses.

1.2 USE OF THE GUIDELINES BY GOVERNMENT AND INDUSTRY

The guidelines are intended to be used by government and industry staff. They provide detailed information:

- What terrestrial vegetation (ecosystems) can be re-established to achieve two land use objectives (commercial forest and wildlife habitat) in the oil sands region,
- How to establish these ecosystems through reclamation techniques, and
- How to monitor whether the reclamation approach has been successful. Information gaps that exist and assumptions that have been made are documented. Research may need to be designed and conducted to fill some of the knowledge gaps.

These guidelines represent a working document that will be reviewed every five years and revised with new information.

2. APPROACH USED TO PREPARE GUIDELINES

This section outlines the guiding principles and process that were used by the Committee to prepare the guidelines.

2.1 GUIDING PRINCIPLES

Guiding principles that were followed in developing the approach to reclamation presented in this document are:

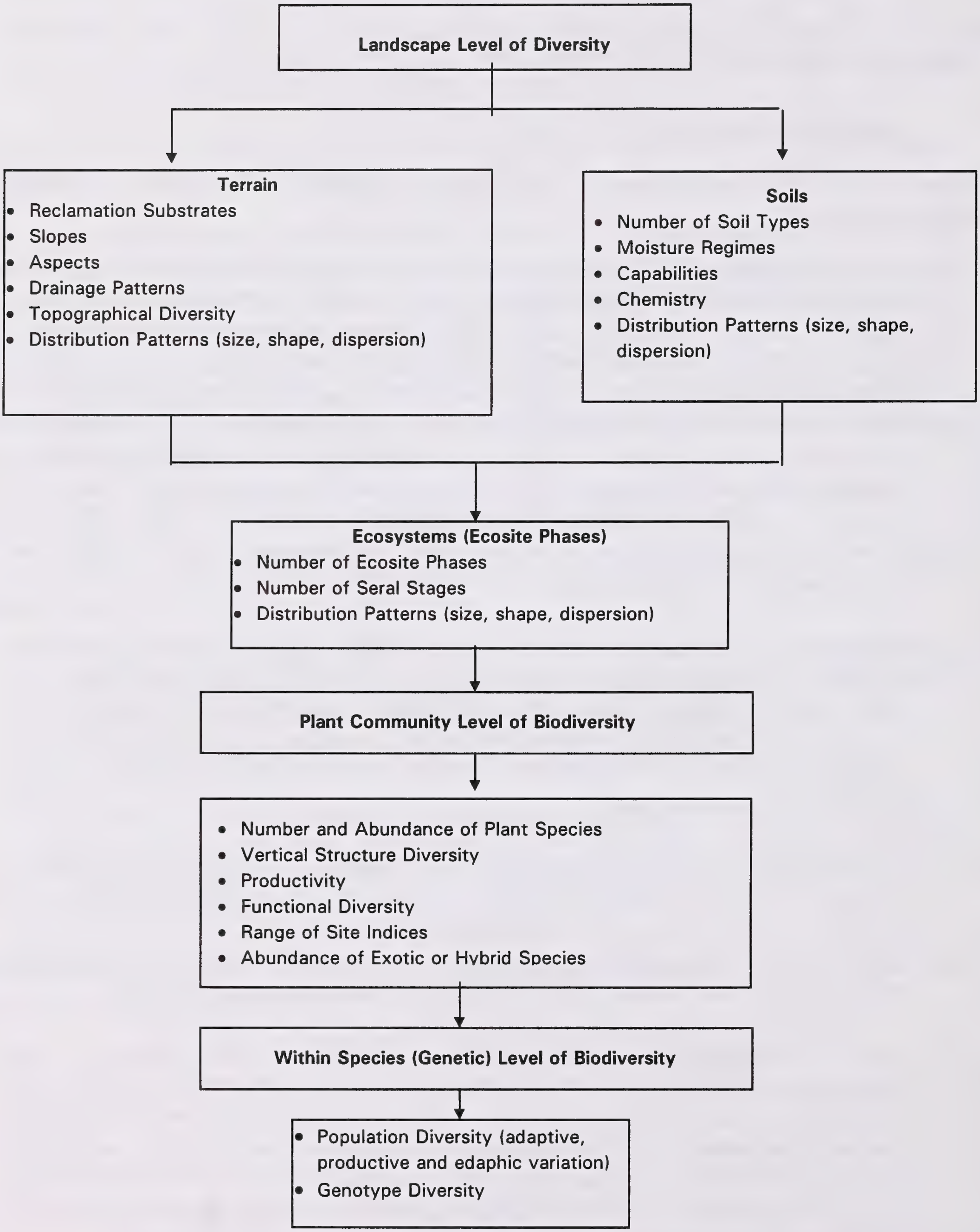
- **Diversity/Biodiversity** – The maintenance of ecological diversity has become a central goal of forest management in Alberta (AFCSSC 1997) and across North America (Hunter 1991; Everett 1993; Grumbine 1994). Consequently, government and industry must monitor forest ecosystems to ascertain if ecological diversity is being maintained as resources are extracted (Noss 1990; Christiensen 1996; AFCSSC 1997). Maintenance of biodiversity is required to meet Canada's and Alberta's commitments made in the National Forest Strategy (CCFM 1992), Canadian Biodiversity Strategy (EC 1995), and Rio Convention (UNEP 1992). In response to these commitments the Canadian Council of Forest Ministers (CCFM 1995) has agreed to a set of criteria and indicators for the sustainable management of Canada's forests.

  Biodiversity is a measure of ecosystem sustainability as represented by the range in variety of biotic and abiotic components at landscape, plant community and within species (genetic) levels. To successfully reclaim lands to a sustainable ecosystem, the vegetation systems should have a range of biodiversity similar to predisturbance values. Figure 2.1 outlines the types of biodiversity to be addressed during reclamation.

  The creation of a variety of macro and micro landform components and soils on the reclaimed areas is required to create a range of ecosystems (ecosite phases) and hence biodiversity at the landscape level (Figure 2.1). By combining the landform components with biotic components, and further enhancing with spatial variability, the opportunity to approach predisturbance biodiversity exists.

  Time is another key element in creating biodiversity levels similar to the predisturbance levels. Creation of a diverse landscape will certainly enhance the opportunity for species variation but this will not happen in the first year after the area has been reclaimed. The objective for industry will not be to try and create the level of biodiversity in year one that is characteristic of a mature ecosystem, but to provide the key elements to each site that will create an environment that over time will reach acceptable levels of biodiversity.

Figure 2.1 Types of Diversity/Biodiversity to be Addressed During Reclamation



The plant community level of biodiversity addresses the number and abundance of plant species in ecosystems, the diversity of vegetation forms (vertical structure), productivity and functional diversity (Figure 2.1).

Conserving genetic diversity, and particularly population diversity, is the key element to ensuring that species retain their capacity to evolve and adapt to change within their environment (Figure 2.1). As genetic diversity is reduced, the risk of genetic maladaptation increases logarithmically. Genetic diversity is essential for sustaining the productive capability and resilience of forest ecosystems. Therefore, genetic diversity is the fundamental basis of the diversity of all species and the sustainability of the ecosystems.

To re-establish equivalent land use capabilities, careful consideration should be given to the component choices required to satisfy the needs of biodiversity, the types of commercial forest, wildlife habitat and other uses.

When planning mine and facility development, and during operational phases, careful consideration should be given to the preservation of refugia. *Insitu* conservation includes leaving original ecosystems intact from which diverse genetic plant material can emanate and provide for a variety of native species. In addition, consideration should be given to selecting vegetation species for reclamation that do not adversely impact surrounding ecosystems by preventing long-term restoration of biodiversity to natural levels.

Documents that support and give direction for biodiversity in forested landscapes include:

- The Canadian Framework of Criteria and Indicators for Sustainable Management and Defining Sustainable Forest Management, A Canadian Approach to Criteria and Indicators, published by the Canadian Council of Forest Ministers (CCFM 1995),
- The proposed Forest Conservation Strategy, Alberta Environmental Protection, Land and Forest Service, Alberta Environmental Protection (AFCSSC 1997), and
- Ecological Diversity Monitoring Framework, Draft #6, Prepared for the Biodiversity Monitoring Working Group (Schneider 1997) (Appendix E).

- **Sustainability** - Sustainable ecosystems are able to adapt and evolve over time.
- **Adaptive Management Approach** – Reclamation approaches and techniques should be regularly improved based on the results of ongoing research and routine monitoring.

- **Productivity** - Forest productivity across the landscape should be re-established to levels that existed before the mining operations were initiated. Productivity is defined as the site index at 50 years.

- **Ecosite** - The ecosite classification system for northern Alberta (Beckingham and Archibald 1996) was used as a guide to select plant species for reclamation. The definitions of ecosite, ecosite phase and plant communities are presented in the Glossary of Terms (Section 8) and in Appendix A.

- **Native and Exotic Species** – Plant species native to the Central Mixedwood Natural Subregion should be used for reclamation. Exotic species should not be used in operatonal practices, but can be used in research testing. Appendix D provides an overview of research on plant varieties.

- **Starter and Early Successional Plant Species** –Tree and shrub species used to initiate the establishment of plant communities should be capable of surviving under site conditions characteristic of early successional stages for each ecosite. Other species representing later stages of succession may invade reclaimed areas naturally over time.

- **Cost-effective Implementation** - Reclamation should be conducted to re-establish viable ecosystems in the most efficient and cost-effective manner possible. Reclamation should take advantage of direct placement of soil materials and other cost-effective opportunities as they become available.

2.2 PROCESS FOR ESTABLISHING VEGETATION (ECOSYSTEMS) TO MEET VARIOUS LAND USE OBJECTIVES

The Committee designed a seven step process to evaluate which ecosystems could be established to support terrestrial land use objectives on oil sands leases, and what techniques should be used to establish the preferred ecosystems. The term "ecosite" or "ecosite phase" will be used in place of ecosystem throughout the rest of this document. These terms are defined in the Glossary of Terms (Section 8) and in Appendix A. The seven steps are illustrated in Figure 2.2, and are described in the following text. The steps include:

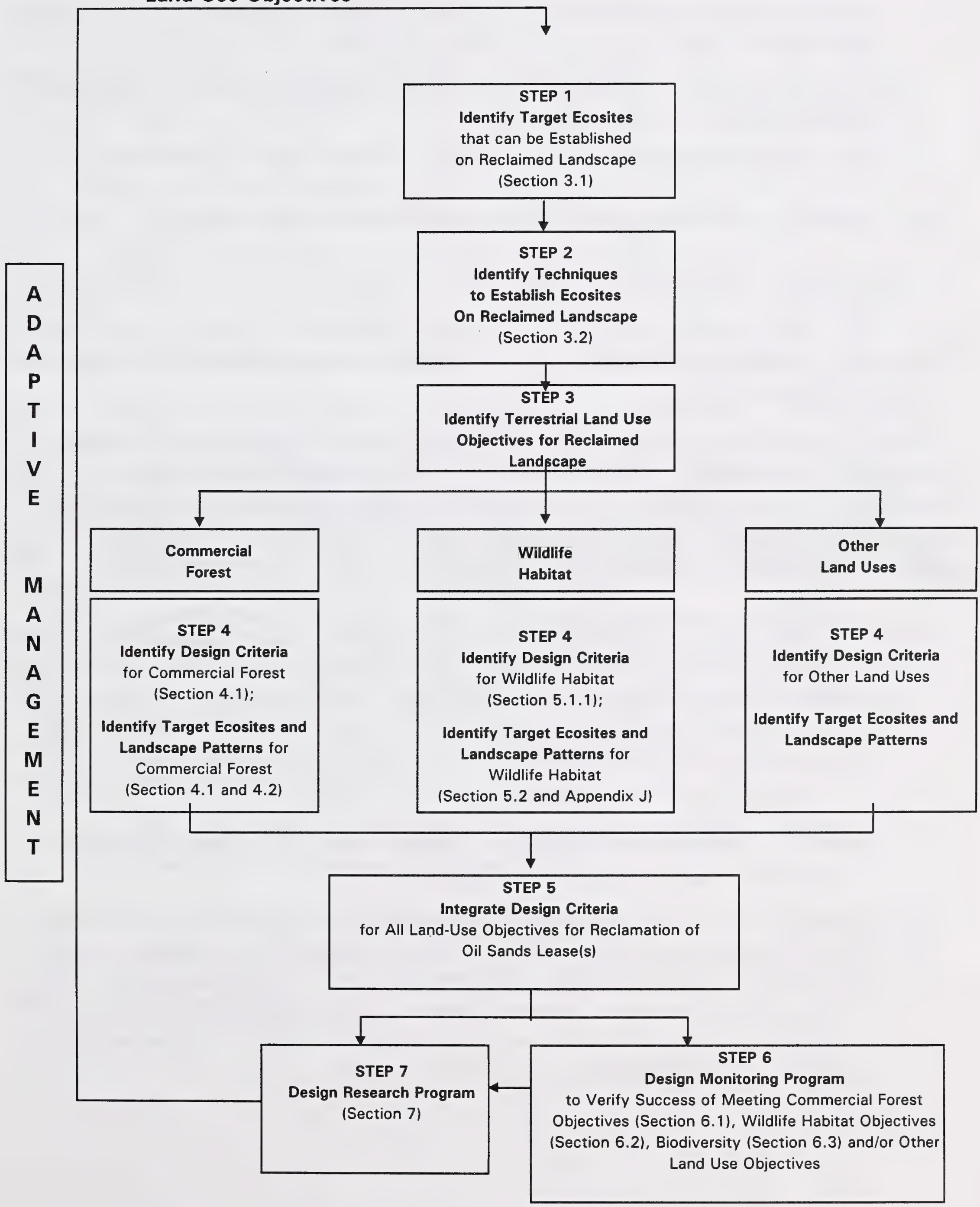
1. Identify Target Ecosites that can be Established on Reclaimed Landscape.

2. Identify Techniques to Establish Ecosites on Reclaimed Landscape.

3. Identify Terrestrial Land Use Objectives for Reclaimed Landscape.

4. Identify Design Criteria for Ecosystems and Landscape Patterns to Achieve the Selected Terrestrial Land Use Objectives (i.e., commercial forest, wildlife habitat and other).

Figure 2.2 Flow Diagram of Process for Establishing Vegetation (Ecosites) for Different Land Use Objectives



5. Integrate Design Criteria for all Land Use Objectives for Reclamation of Oil Sands Leases.
6. Design Monitoring Programs to Verify that Land Use Objectives have been Successfully Met.
7. Recommend Research Programs to Address Information Gaps on Reclamation.

Step 1 - Identify Target Ecosites to be Established on Reclaimed Landscape

The first step was to identify which ecosites, of those that occur in the oil sands region, can be supported on reclaimed landscapes. The ecosites that naturally occur in the oil sands region were identified based on the ecological classification system for the Boreal Mixedwood produced by Beckingham and Archibald (1996) entitled "Field Guide to Ecosites of Northern Alberta".

Of the ecosites that exist in the region, those that can be re-established on reclaimed landscapes were identified. The ecosites that can be re-established will depend on the landscape, drainage and soils that are re-established within the reclaimed landscapes, and hence on the available moisture and nutrient regimes. Therefore, to determine which ecosites can be established on reclaimed oil sands leases, two tasks were completed.

- Landscape features including slope, aspect, drainage pattern (moisture regime) and reclamation substrate, and the types of soils that can be established on oil sands leases were identified. Information was based on current mining and reclamation techniques that are being used on the Syncrude and Suncor oil sands leases. Several soil types can be reconstructed on tailings sand, overburden and consolidated/composite tailings (CT). For each soil type, the soil capability for forest ecosystems (based on Leskiw 1998), potential moisture regimes, potential nutrient regimes and salinity were identified. Three landscape features were classified: slope, aspect and reclamation substrate (overburden, tailings sand and CT), and

- Based on the known ecological requirements for the various ecosites (broad nutrient and moisture regimes) and for plant species in northeastern Alberta (Beckingham and Archibald 1996) and "Forest Sites Interpretation and Silivicultural Prescription Guide for Alberta" (Alberta Environmental Protection 1996a), the types of ecosites and plant species that could be supported by the reconstructed landscapes and soils were identified.

Step 2 - Identify Techniques to Establish Ecosites on Reclaimed Landscape

Using information from the extensive research and monitoring programs conducted by Suncor and Syncrude over the past several years, and the list of plant species associated with various ecosite phases (Beckingham and Archibald 1996), techniques were identified that could be used to reconstruct the landscape and soils, and to initiate "starter vegetation" that should eventually succeed to the targeted ecosites. Techniques outlined include: preferred landscape and soil reconstruction methods to establish Class 2 and 3 soil capabilities for forest ecosystems (these are based on presently used construction techniques), preferred revegetation methods such as planting densities, fertilizers, and preferred tree and shrub species. In addition, information has been provided on preferred sources of seeds and potential herbaceous and native species that may invade reclaimed sites.

Step 3 - Identify Terrestrial Land Use Objectives for the Reclaimed Landscape

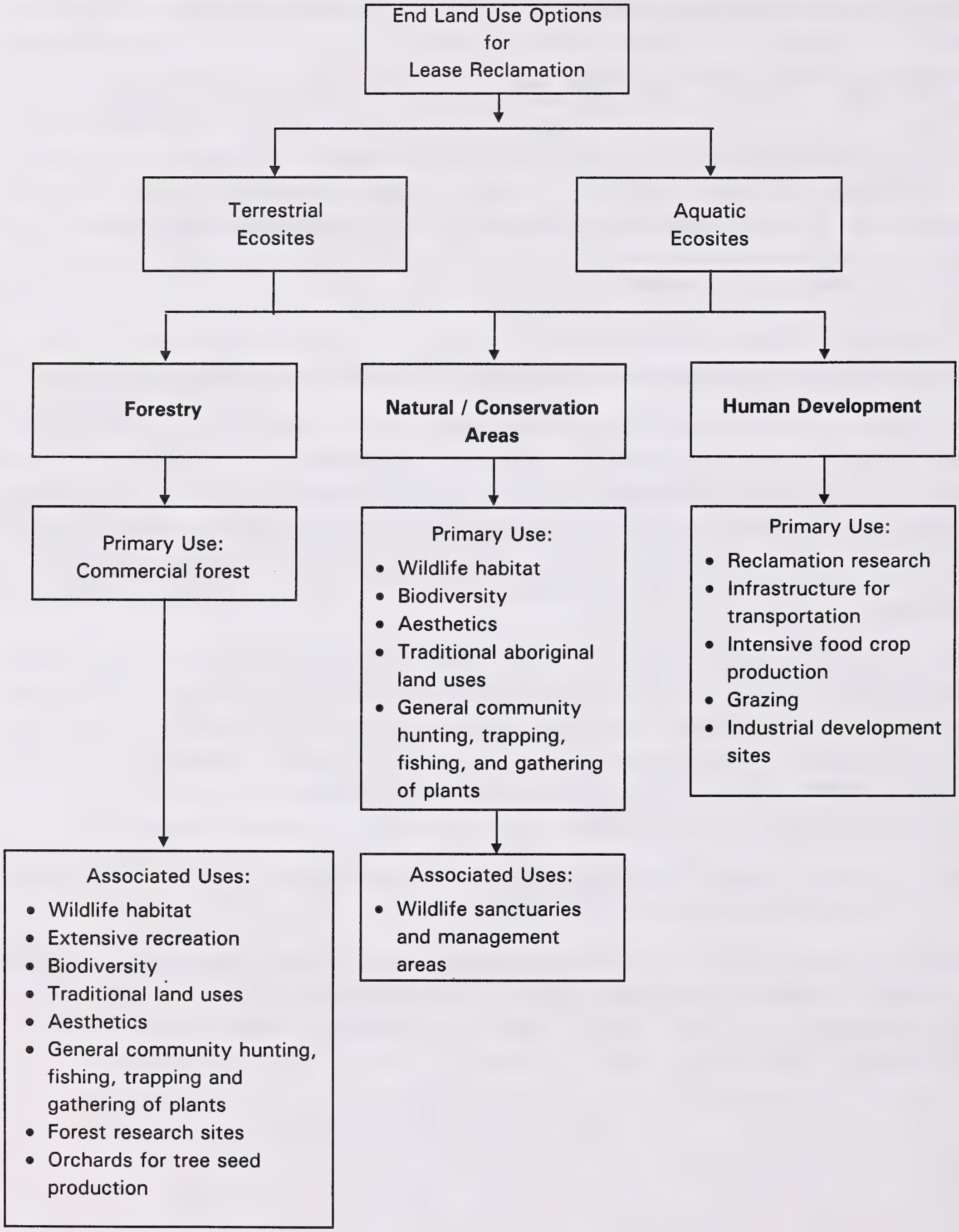
The third step was to identify land use objectives in the oil sands region. The Oil Sands End Land-Use Committee has worked with key stakeholders in the region to define allowable land use options (Figure 2.3). The Oil Sands Vegetation Reclamation Committee chose to look at two acceptable objectives within a forest ecosystem: the primary land use of commercial forest for timber production, and the associated use of wildlife habitat. Other land uses that could be examined at a later date include recreation, traditional use and others as shown in Figure 2.3.

Each oil sands lease will be designed for several integrated land uses. The oil sands developer will negotiate what portion of their oil sands lease will be allocated to each land use based on the guidelines recommended by the Oil Sands End Land-Use Committee. The expectation is that each re-established ecosystem will support several land uses. For example, a commercial forest designed to produce timber will also provide habitat for wildlife and recreational opportunities.

Step 4 - Identify Design Criteria for Ecosystems and Landscape Patterns to Achieve the Selected Terrestrial Land Use Objectives

The fourth step in the process was to identify the design criteria required for the reclaimed landscape to support commercial forest and wildlife habitat. Design criteria included information on the preferred types of ecosites and preferred patterns of distribution of ecosites in the landscape.

Figure 2.3 End Land Use Options Recommended by Oil Sands End Land-Use Committee. Shaded Boxes Represent the Land Use Objectives Addressed in this Document.



Commercial Forest: "The Forest Site Interpretation and Silvicultural Prescription Guide" (Alberta Environmental Protection 1996a), and the "Provincial Timber Harvesting Planning and Operations Ground Rules" (Alberta Environmental Protection 1994a), were used to identify important landscape and vegetation design criteria to be used for commercial forest. These criteria identify the forests that may be considered commercial within normal operating standards. Only forest stands of acceptable tree species that provide adequate volumes of timber at maturity (i.e., based on tree age, diameter at breast height, height and tree density) are considered merchantable. Additionally, only a subset of merchantable forests are accessible for the harvesting of timber and, hence are considered to be commercial. Merchantable stands that are located on steep slopes or within protective buffers around watercourses and wetlands, or are too small and not economical to retrieve (ground rule constraints), are considered non-commercial. The productivity (volume and growth) on the reclaimed landscape should meet or exceed predisturbance productivity levels.

Wildlife Habitat: Ecological (biophysical) factors that directly influence the suitability of habitat for wildlife include vegetation cover type, slope, aspect and other topographic features. Good habitat provides a combination of high quality food and cover for species of wildlife. Although all vegetation types provide some potential value or suitability for most species of wildlife, each group of species prefers certain ecological factors that better meet their requirements.

Habitat can be re-established based on either a coarse or fine filter approach. The objective of the coarse filter approach is to re-establish the same types of vegetation communities, in the same abundance and dispersion patterns, as existed prior to disturbance. This is pursued with the expectation that wildlife populations will return to the reclaimed sites in the same composition and abundance as existed prior to disturbance. This approach is meaningful and can be achieved by meeting biodiversity objectives as outlined in Sections 2.1 and 6.3. The objective of the fine filter approach is to reclaim an area to provide the specific biophysical habitat requirements of indicator wildlife species. This approach is outlined for ten wildlife indicator species in Appendix J.

Step 5 - Integrate Design Criteria for all Land Use Objectives for Reclamation of Oil Sands Leases

It is intended that lease holders will design their landscapes to achieve the required land uses using this document to assist with planning. Once the design criteria for each of the primary and associated land uses have been identified, the distribution pattern of the preferred ecosites for the primary land use over the development leases needs to be identified. Then the design criteria for the associated uses need to be integrated into the design criteria for the primary use. This is an important planning exercise that should be

completed by an operator of an oil sands development during the design of the closure plan. This step is not discussed further in this manual.

Step 6 - Design Monitoring Program to Verify That Land Use Objectives Have Been Successfully Met

The sixth step in the process was to design monitoring programs to determine if the land use objectives have been achieved. For commercial forest and wildlife habitat, the benchmark to assess whether the reclamation approach has been successful has been identified and potential monitoring programs have been described.

For example, to ensure the objectives of establishing a commercial forest are being achieved, two monitoring programs are recommended:

- A program to confirm the establishment of tree seedlings, as benchmarked through compliance requirements under the "Timber Management Regulations" and the "Regeneration Survey Manual" (Alberta Environmental Protection 1994b), and

- A program to verify the establishment of forest productivity as benchmarked through measures of tree height growth, mean annual increment and site index, and its linkage to the measurement of soil capability.

Monitoring programs have also been presented for biodiversity. Specifically, the establishment of biodiversity is benchmarked through the variety of plant communities, plant species and diversity within species that become established, as compared to the pre-disturbance situation.

If results from the monitoring programs indicate that the land use objectives are not being achieved, the guidelines in this document for each of the steps in the process will be revised.

Step 7 – Recommended Research Programs to Address Information Gaps on Reclamation

The seventh step was to identify research needed to address information gaps identified in the reclamation information. In addition, research programs to pursue potential areas of improvement in reclamation techniques will be developed on an ongoing basis as monitoring data identifies these needs. New research and monitoring information will then be used to understand what additional ecosites can be established, and to improve the techniques used to establish these ecosites. This latter step follows the principle of Adaptive Management.

3. ECOSITE ESTABLISHMENT

The first step in the process was to identify which ecosystems of those that occur in the region, can be supported on reclaimed landscapes. The ecosystems that naturally occur in the oil sands region were identified based on the ecological classification system produced by Beckingham and Archibald (1996) for the Boreal Mixedwood. There are 12 ecosites (based on moisture and nutrient regimes), 25 ecosites phases (based on similar dominant plant species) and 73 plant community types (based on similar understorey species composition and abundance). The ecological classification system is detailed in Appendix A. Of those ecosites available in the region, the ecosites that could be supported on reclaimed landscapes, based on the re-established topography and soils were identified.

3.1 ECOSITES TO BE ESTABLISHED ON RECLAIMED LAND

The "Land Capability Classification for Forest Ecosystems" (Leskiw 1998) as it is applied to land reclamation has two main components: soils and landscape. Each component is evaluated separately, then the overall rating is determined by the most limiting of the two. The rating system has 5 classes, with Class 1 lands having the highest capability for forest ecosystems, and Class 5 lands having no potential for forest ecosystems. Climate also affects vegetation but it is assumed to remain unchanged so it does not affect the ratings before and after land disturbance.

In the soils component of the capability classification, the emphasis on soils is at a series level, and capability is closely related to productivity. The focus is on soil chemical and physical properties (reaction, salinity, nutrients, texture, structure, consistence, water retention, and moisture regime), and the resultant quality of the root zone.

A review of the ecosite classification of the boreal forest (Beckingham and Archibald 1996) reveals a close relationship among ecosite phase, site index and soil capability (Table 3.1). Table 3.2 provides a summary of the relationship among ecosite, moisture regime, site index, soil subgroup and soil capability for forest ecosystems across the boreal forest.

A synopsis of principal soils (soil series) as reclaimed to date on the Syncrude and Suncor oil sands leases is given in Table 3.3. These are also targeted soils for future reclamation along with corresponding targeted ecosite types. There will also be soils developed on consolidated/composite tailings (CT) in the future, but these soil types are not addressed in this document.

Table 3.1
Regional Mean Site Index by Species for each Ecosite for the Boreal Mixedwood, Northern Alberta

Ecosite	Moisture Regime	Indicator Species	MEAN SITE INDEX AT 50 YEARS				
			Aspen	White Spruce	Jack Pine	Black Spruce	Balsam Poplar
a	xeric 2 subxeric 3	lichen			13.4		
b	submesic 4	blueberry	15.8	17.5	14.3		
c	mesic 5	Labrador tea-mesic			14.3	11.5	
d	mesic 5	low-bush cranberry	18.2	16.8	15.2	15.7	17.3
e	subhygric 6	dogwood	21.4	17.8			19.7
f	subhygric 6 & hygric 7	horsetail	19.8	16.4			17.8
g	subhygric 6 & hygric 7	Labrador tea-subhygric			11.7	9.9	
h	hygric 7	Labrador tea/horsetail		12.9		9.5	
i	subhydric 8	bog				9.8	
j	subhydric 8	poor fen				10.4	
k	subhydric 8	rich fen				7.2	
l	hydric	marsh	Not Applicable				

Source: Beckingham and Archibald (1996). Also see Appendix B for soil and site index relationships found in other applicable studies.

Table 3.2
Summary of Ecosites and Related Site Productivity and Soil Capability for the Boreal Mixedwood, Northern Alberta

Ecosite	Moisture Regime	Site Productivity (Site Index At 50 Years)	Soil Subgroup	Soil Capability Class[a]
Lichen (a)	Xeric 2	10-14	Orthic Brunisols	4
Lichen (a)	Subxeric 3	10-14	Orthic Brunisols & Luvisols	4
Blueberry (b) Labrador tea (c)	Submesic 4	14-18	Orthic Luvisols & Brunisols	3
low-bush cranberry (d)	Mesic 5	14-18	Orthic Luvisols	2
Dogwood (e) Horsetail (f)	Subhygric 6	18-22+	Gleyed Luvisols	1
Horsetail (f) Labrador tea-subhygric (g) Labrador tea/horsetail (h)	Subhygric 6 & Hygric 7	14-18	Gleysols (aerated)	3
Labrador tea-subhygric (g) Labrador tea/horsetail (h)	Hygric 7	10-14	Gleysols (reduced)	4
Bog (i) poor fen (j) rich fen (k)	Subhydric 8	<10	Organic	5
Marsh (l)	Hydric 9	Not Applicable		

Source: Beckingham and Archibald 1996.

Note: Indices commonly ± 1 m.

[a] Soil Capability Class (from Leskiw 1998):

Class 1 – High Capability (Index 81 to 100): Land having no significant limitations to supporting productive forestry, or only minor limitations that will be overcome with normal management practices.

Class 2 – Moderate Capability (Index 61 to 80): Land having limitations which in aggregate are moderately limiting for forest production. The limitations will reduce productivity or benefits, or increase inputs to the extent that the overall advantage to be gained from the use will be still attractive, but appreciably inferior to that expected on Class 1 land.

Class 3 – Low Capability (Index 41 to 60): Land having limitations which in aggregate are moderately severe for forest production. The limitations will reduce productivity or benefits, or increase inputs to the extent that the overall advantage to be gained from the use will be low.

Class 4 – Conditionally Productive (Index 21 to 40): Land having severe limitations; some of which may be surmountable through management, but which cannot be corrected with existing knowledge.

Class 5 – Non-Productive (Index 0 to 20): Land having limitations which appear so severe as to preclude any possibility of successful forest production.

Table 3.3
Reclaimed Soils, Soil Capability and Target Ecosites

Soil Series[a]	Reclaimed Soils (Depth ±5 cm)	Soil Capability	Drainage Class[c]	Moisture Regime[d]	Nutrient Regime	Electrical Conductivity (dS/m)	Target Ecosite[e]
A	20 cm peat-mineral mix/ 30 cm clay/TSS[b]	2	W-MW	mesic	medium	<1	d
		1	I	subhygric	medium	<1	d-e
B	50 cm clay/TSS	3	W-MW	mesic	low	<1	c
		2	I	subhygric		<1	g
C	50 cm sandy loam/TSS	3	R-W	submesic	low	<1	a,b
D	20 cm peat-mineral mix/ 30 cm sandy loam/TSS	3	W	mesic	medium	<1	d
		2	I	subhygric	medium	<1	d-e-f
E	20 cm peat-mineral mix/ 30 cm clay/OB[b]	3	W-MW	mesic	medium	3 (2-4)	d
		2	I	subhygric	medium	3 (2-4)	d-e-f
F	50 cm clay/OB	3	W-MW	mesic	low	3 (2-4)	c
		2	I	subhygric	low	3 (2-4)	g
G	Overlay of > 50 cm TSS	4	R-W	subxeric	low	< 1	a
H	20 cm peat-mineral mix/TSS	3	R-W	submesic	medium	<1	b
		2	I	subhygric	medium	<1	d-e-f
I	20 cm peat-mineral mix/OB	3	W-MW	mesic	medium	3 (2-4)	d
		2	I	subhygric	medium	3 (2-4)	d-e-f
J	100 cm peat-mineral mix	2	W-MW	mesic	medium	<1	d-e
		4	VP	subhydric	medium	<1	g,h,i,j,k
K	100 cm mineral soil	4	P	hygric (r)	low	<1	g, h
		5	VP	subhydric	low	<1	I,j,k
L	20 cm peat-mineral mix/ 80 cm mineral soil	4	P	hygric (r)	medium	<1	g, h
		5	VP	subhydric	medium	<1	I,j,k

(a) Soil series are designated with capital letters and these do not correspond to ecosite types which are shown in lower case letters.

(b) Reclaimed soils substrate materials: TSS = tailings sand; OB = overburden, usually oily; pH levels of all reclaimed materials about 7.5.

(c) Drainage Class: R-rapid; W-well; MW-moderately well; I-imperfect; P-Poor; VP-very poor.

(d) This is the expected upland moisture regime. Lower slopes and level areas may become wetter. Also, on slopes >20%, north aspects (270° - 135°) will be one moisture regime class wetter, and south aspects (135° - 270°) will be one moisture regime class drier. See Section 8 – Glossary of Terms for definitions of moisture classes.

(e) Names of ecosites are listed in Table 3.2.

The resultant soil and landscape capability classes are used for comparison with baseline conditions. Appendix B provides descriptions of natural baseline soils in the region and corresponding site indices for principal tree species. To augment the "equivalent capability approach", it is recommended that forest productivity be confirmed on the principal soils, both before and after reclamation. This can be accomplished by determining site index of principal tree species, in suitable stands (considering age, density and health), at the same location where soil descriptions are made on reclaimed areas.

The assumption made in predicting ecosites is that much of the "upland" landscape will be rapid to moderately well-drained, corresponding to submesic to mesic moisture regimes. Areas with a peat-mineral mix application will tend to have a medium nutrient regime. The reclaimed soils in each ecosite will differ from natural soils in the matching natural ecosite. Reclaimed soils will tend to have higher pH levels (6.5 to 8.0), and there will likely be higher salinities ranging from electrical conductivity (EC) of 0.5 to 4.0 dS/m in the root zone. Nevertheless, ecosites should develop with productivity levels similar to those in natural ecosites. The above soils can be established on a variety of landscapes, including dyke slopes and level to undulating areas.

The target ecosites that may establish on each of the principal soils (soil series) that have been reconstructed by Syncrude and Suncor are listed on Table 3.3. The ecosites range from those that will establish on low nutrient, drier sites (subxeric, submesic) such as the lichen (a) and blueberry (b) ecosites to those that will establish on wetter (mesic, subhygric), higher nutrient sites such as low-bush cranberry (d), dogwood (e) and horsetail (f).

In time, lower areas, especially on overburden landscapes, may become imperfectly drained (subhygric or hygric). Depending on the degree of wetness, tree growth may be enhanced or retarded. The enhanced growth areas should be suitable for e-type (dogwood) ecosites, whereas wetter areas are destined for g (Labrador tea-subhygric), h (Labrador tea/horsetail) and I (bog) ecosites.

3.2 ESTABLISHMENT OF ECOSITES ON RECLAIMED LANDSCAPES

Reclamation techniques used currently and historically by Suncor and Syncrude are outlined in Appendix F. This section presents a summary of current starter reclamation practices and methods to establish landscape and soils for ecosite development.

3.2.1 Reclamation Goals

The goal of reclamation is to achieve maintenance-free, self-sustaining ecosystems with capabilities equivalent to or better than pre-disturbance conditions. Maintenance-free reclamation means that human maintenance activities are not required, except for circumstances where future human activities lead to re-disturbance of areas. This does

not imply a changeless state, as landforms will experience gradual reshaping of the landscape through normal geologic processes typical of the region and vegetation will evolve through various seral stages to more mature ecosystems over time. Self-sustaining ecosystems, typical of those in the region, will evolve on revegetated terrains, from new plantings toward mature systems typical of those in the region, with little management input from man following the initial plant establishment. Equivalent land capability refers to the capability of post-reclamation land to support various land uses similar to those that existed prior to an activity being conducted on the land; however, individual predisturbance and post-reclamation land uses may not be identical.

The vision for reclamation includes the construction of stable landforms and re-establishment of productive, self-sustaining ecosystems which will provide land use capabilities equivalent to those of the pre-mining environment. The following general operational and reclamation criteria form the basis for reclamation program design:

- Structures will be geotechnically stable,
- Discharge of earth materials through surface erosional processes will be controlled to rates which are acceptable to the environment,
- Discharge of surface and seepage waters will be managed to ensure an acceptable level of impact on watercourses, and
- The ecosystems re-established on disturbed lands will be self-sustaining and will mature naturally without presenting significant risk to plants, or resident and migratory wildlife species.

3.2.2 Landscape and Soil Construction

Landscape evaluation focusses on general tree growth (aspen, white spruce, jack pine) as determined primarily by steepness of slope and modified by effects of slope position and aspect, stoniness, and actual erosion. As a guide, slopes for each landscape capability class are: Class 1 is <30%, Class 2 is 31-45%, Class 3 is 46-60%, Class 4 is 61-75%, and Class 5 is >75%. Position effects are considered to impact a rating by one-half a class: moisture shedding positions are downgraded, moisture receiving positions are upgraded, level areas remain unchanged, and depressional areas are downgraded. South-easterly to westerly exposures (Figure 3.2) on slopes >20% are also downgraded by about one-half class. Northerly aspects have cooler temperatures offset by improved moisture balance, resulting in no change to the class. Stoniness reduces rooting volume and can downgrade landscapes from Class 1 to Class 5 as volume of stones increases from <20% to >80%, respectively. Erosion (visible rills and gullies) can downgrade the landscape as much as two classes (for example, Class 2 soil on a 35% slope downgraded to Class 4 if erosion is extreme). Refer to the "Land Capability Classification for Forest Ecosystems in the Oil Sands Region" (Leskiw 1998) to rate specific landscape conditions.

3.2.2.1 Terrain Development

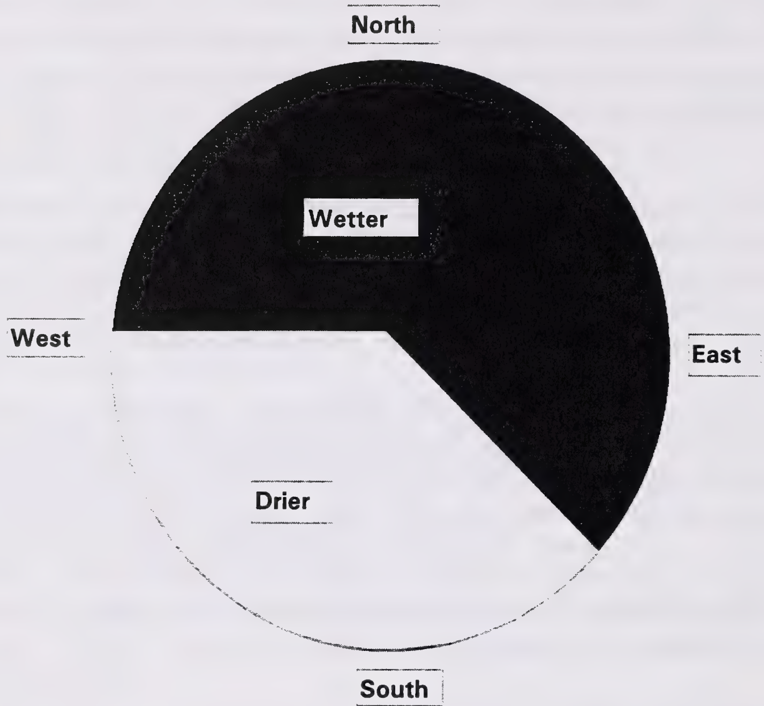
Existing landforms are altered as a result of mining. Flat and depressional areas will be replaced by more upland landforms with slopes up to 3:1 (horizontal:vertical). These new areas will be better drained than the pre-existing landforms. Tailings dyke structures are designed to provide secure impoundment of tailings (fines in suspension, tailings water and consolidated/composite tailings (CT)). Tailings materials will be reclaimed in two ways. Fluid or mature fine tails will be placed below a cap of clean water, while CT is expected to develop into a dryland/wetland system and be revegetated. Overburden dumps are created to store overburden materials comprised of recent fluvial deposits, a variety of glacial deposits, and bedrock formations including hydrocarbon enriched materials. The topography of overburden dumps ranges from level to steeply sloping. Slope stability of overburden materials and chemical composition (salinity and sodicity) are important considerations in final design and resultant soil and landscape capability.

Peat-mineral mix materials may also be stockpiled, temporarily and possibly permanently. The intent is to salvage peat deposits (organic soils) for future reclamation purposes. Findings to date suggest that pure peat stockpiles may be droughty in mesic or drier moisture regimes, and they may develop permafrost in wetter moisture regimes. Peat-mineral mixes (4:1 peat: mineral ratio or less peat) appear to behave as a mineral soil without drought or frost problems. Therefore, in stockpiling peat, it is recommended that peat be overstripped to incorporate at least 20% (by volume) mineral material, as is currently practiced for placement as a surface soil.

3.2.2.2 Terrain Stability Objectives

Dyke and dump structures are created with the primary objective of geotechnical stability. This does not preclude making alterations to the final design of these structures while maintaining the stability objective. Long-term post-reclamation landform stability (of all retention structures) is evaluated through ongoing stability monitoring and analyses. These structures have been designed and are operated to accepted Canadian standards. Their design, construction and performance is supported by extensive monitoring programs reviewed by independent review boards and regulatory agencies.

Figure 3.1 The Effects of Aspect on the Moisture Regime



3.2.3 Reclamation Approach

Soil capability is a principal determinant for many terrestrial environmental characteristics. Both vegetation and wildlife habitat, as well as their sustainability and biodiversity are dependent on soil capability. The reclamation objective is to provide equivalent (or better) soil capability (with consequent and equivalent plant and animal ecosystems) as the mine is developed and reclaimed. Annual detailing of soil salvage and reclamation area establishment allows quantification of losses/gains in capability. This is accomplished through use of the land capability classification system for the oil sands area (Leskiw 1998).

The history of reclamation success through vegetation establishment is provided in Appendix H.

3.2.3.1 Soil Reconstruction

Reconstruction of soil for reclamation areas is a critical component of a reclamation plan, since the ultimate capability of the reclaimed area is determined largely by the quality of reconstructed soil. Surfaces of reconstructed landforms are covered with a layer of soil amendment, primarily a peat-mineral mix that has been salvaged from areas to be mined, and then either stockpiled or (preferably) transported directly to reclamation areas (i.e., direct placement). Stockpiling is employed where surface disturbance has just begun on a site and where there are no areas available for reclamation.

Soils are reconstructed using either “one-layer” or “two-layer” soil replacement. In one-layer reclamation, sites are enhanced with quality soil-building material, using a technique which involves overstripping muskeg (peat) to include 25 to 50% (by volume) of mineral overburden (usually 1 m of peat and 0.4 m of mineral overburden). This material becomes the cover soil described as peat-mineral mix amendment. It is hauled, placed on prepared subsoil and then spread to an average depth of 15 to 50 cm over the underlying materials. The subsoil base materials are either tailings sand, suitable overburden or possibly (in the future) CT. Where peat is mixed with fine-textured till, clay or silt (fines), the mixture is primarily used as an amendment for tailings sand areas. Where peat is mixed with coarse textured material (sand and gravel), the mixture is primarily used to amend overburden dumps or dykes.

In two-layer operations, about 50 cm of either sandy or clayey suitable subsoil material is placed over tailings sand, suitable overburden, or possibly (in the future) CT. The mineral soils are carefully selected with respect to texture and salinity/sodicity to ensure they result in a suitable root zone medium. In the final lift, 15 to 25 cm of cover soil (peat-mineral mix amendment) is placed on top of the subsoil layer.

Modifications of the above procedures occur. In the event that peat-mineral mix material is unavailable as a cover soil amendment, 50 to 70 cm of sandy or clayey soil material that is slightly enriched with organic matter may be placed over tailings sand or suitable overburden. If there is a surplus of peat-mineral mix material, a 1 m layer can be placed over tailings sand, overburden or CT, resulting in a high soil capability rating.

Overburden dumps created from overburden materials consisting of the "Clearwater Formation" and the "McMurray Formation" require additional thickness of cover soil due to their high sodicity and salinity. Depending on the percentage of these types of materials in the dumps, the cover soil cap requires an additional 50 cm of non-sodic overburden, overlain by 50 cm of peat-mineral mix for a total depth of 1 m.

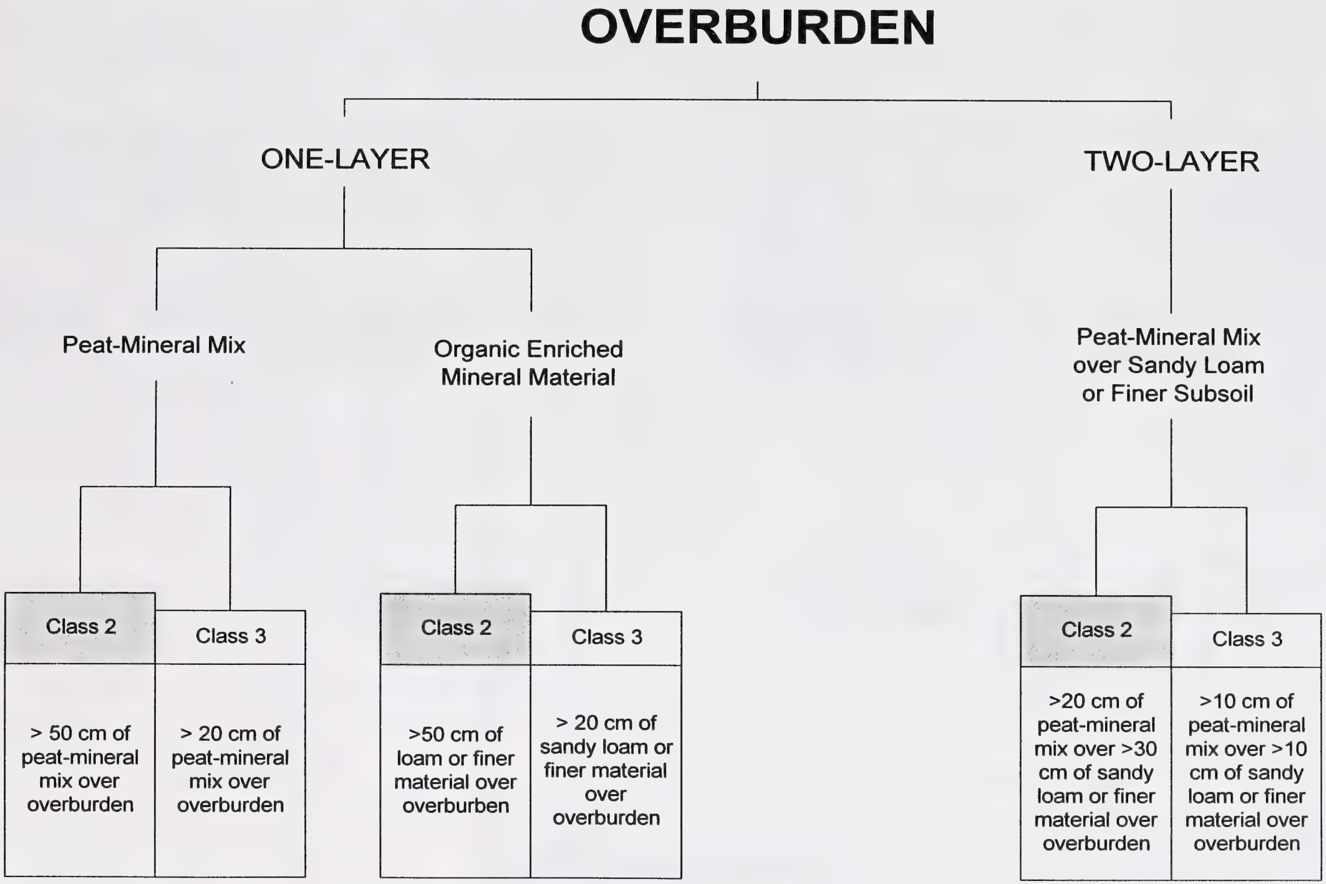
All of the above reclaimed soils normally have a mesic moisture regime. Drier conditions occur on dyke crests and steep south slopes. Wetter conditions commonly develop at the toe of slopes and in depressions within overburden dump areas.

This system of soil salvage has been integrated with the land capability classification (Leskiw 1998) to ensure that the desired land capabilities are achieved. Therefore, peat-mineral mix amendment will be salvaged and directed to the reclamation sites with forest capability development as the primary consideration. This change in focus is not expected to drastically alter soil salvage criteria, but will assist in managing the placement of the better-suited reclamation amendments. As a result, peat-mineral mix soil amendments having a granular subsoil will be directed to sites with a higher proportion of fines in the pre-reclamation soil mix. Peat-mineral mix soil amendment with a higher fines ratio will be directed to areas with a tailings sand or CT substrate. This strategy will result in better water infiltration for the overburden reclamation sites and improved water holding capability for the reclaimed soils on tailings sand and CT.

3.2.3.2 Reclaimed Soils

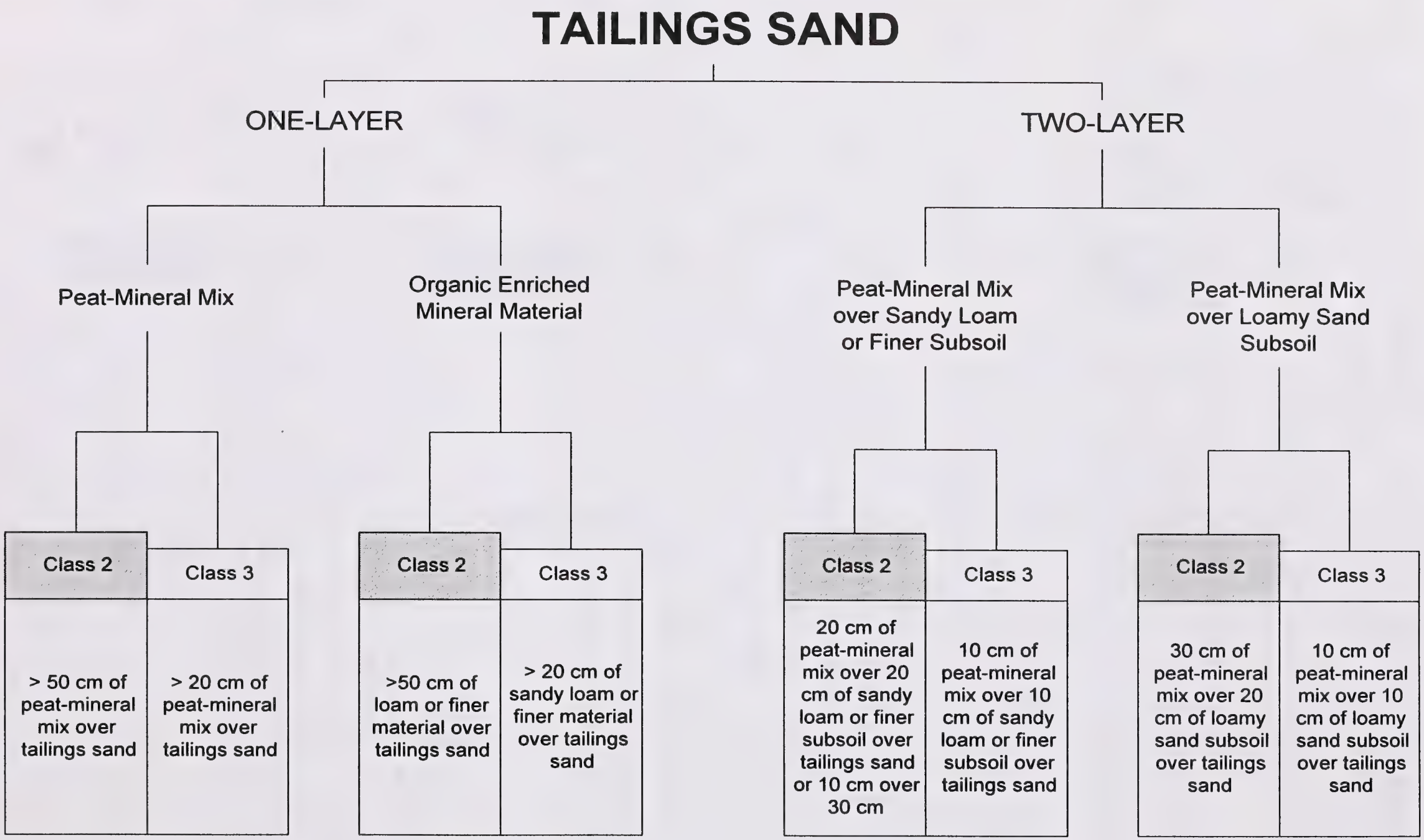
Several reclamation profiles are illustrated in Figures 3.2 and 3.3 based on materials available and conditions encountered during an inventory of reclaimed soils at Syncrude and Suncor. These figures indicate some common reclamation options. A complete rating of specific soils is required to confirm the ratings and to ensure all soil factors are evaluated. Important assumptions made in rating these selected profiles are that the pH of all materials is 7.5 and there are no salinity or physical limitations in topsoils and subsoils except that overburden materials are saline with electrical conductivity levels of 3.5 to 4.5 ds/m.

Figure 3.2 Soil Handling Options and Related Soil Capability Classification for Overburden Reclamation



Assumptions: All materials have a pH of 7.5. EC levels are <2 dS/m in all materials except for the overburden material, which has an EC of 3.5 to 4.5 dS/m.

Figure 3.3 Soil Handling Options and Related Soil Capability Classification for Tailings Sand Reclamation



Assumptions: All materials have a pH of 7.5, and an EC of <2 dS/m.

The most important soil properties considered are depths of materials, along with their respective texture, structure/consistence, salinity and organic matter content. The loamy and clayey textures are superior in retaining water. However, if compaction occurs during placement, these finer textured soils are limiting to root growth. Any direct placement material or overburden should not be saline or sodic. If such limitations occur, the soils are downgraded at least one class. Organic matter in the upper profile is fundamental to vegetation development and should be given special attention in materials handling.

It is important to note that the profiles illustrated in Figures 3.2 and 3.3 are not prescriptions or endorsements for constructing all classes of soils. The intention is: to select the desirable level(s) of reclaimed soil capability, examine alternatives to obtain that level, and choose the best option based on source materials hauling distances and timing. The Class 2 soils in Figures 3.2 and 3.3 respectively, represent the best treatments. The Class 3 soils are created using materials of lower organic matter content, or lower water holding capacity, or by placing shallower depths of better quality materials. In locations where a subhygric moisture regime develops, Class 2 soils are upgraded one class in rating to Class 1 because of improved water availability for plant growth.

3.2.3.3 Vegetation Establishment

Revegetation Objectives

The primary objectives of revegetation programs are to:

- Provide an erosion-resistant plant cover on tailings dyke slopes and overburden dump slopes,
- Focus on utilization of native woody-stemmed reclamation species common to the region,
- Strive to establish a diverse range of plant species to re-create the level of biodiversity common to the pre-disturbed site, and
- Establish a viable plant community capable of developing into a self-sustaining cover of species suitable for commercial forest, wildlife habitat, traditional land uses, and with possibilities for recreation and other end uses.

Current Revegetation Practices

The revegetation of reclaimed landform surfaces is determined by the nature and type of landform structures (dykes, overburden dumps, tailings sand basins, CT deposits), slope, aspect, soil type (capability class) and soil moisture regime. The types of vegetation communities that will successfully establish and develop under various combinations of these factors have been the subject of Suncor and Syncrude research programs for more than 20 years.

Typically, the revegetation process begins with excavation and hauling of undisturbed peat-mineral mix soils to the reclamation area. This method (which is completed in the winter whenever possible) enhances site revegetation because dormant, *insitu* native seeds and root fragments are transferred with the soil. Spreading of the amendment on the reclamation site is completed in early spring with the usual result being the emergence of a variety of native, woody-stemmed species, forbs and grasses beginning in the first growing season.

Tree Planting Prescription

Establishment of woody plants on reclamation areas is integral to the reclamation process. Selection of species and the proportion of each species in the supplemental planting mix are based on the woody-stemmed species common to the ecosites within the region, existing field conditions, the vegetation type expected to develop on the site (based on landscape terrain features), and the expected growth of woody-stemmed species from seeds and root fragments in the soil amendment layer. The species composition is designed to accelerate the process of natural succession towards desired vegetation types (ecosites). The micro-environments in the area change as woody cover develops on a reclamation area, providing favorable conditions for later successional species. The planting program is designed to ensure that plant species that are capable of taking advantage of these changes in condition are present. Therefore, four to six species are typically planted to supplement the natural processes of woody plant establishment. Table 3.4 outlines the starter woody stemmed planting prescriptions to establish each of the ecosite phases.

Fertilizer Application

Fertilizer is applied to both the reclaimed overburden and tailings sand areas following soil placement. Syncrude does not apply maintenance fertilizer to reforested areas, whereas Suncor applies fertilizer annually for two to four years after planting. Maintenance fertilizer rates are determined from criteria such as soil tests, cover performance and cover objectives.

Table 3.4
Planting Prescription by Ecosite Phase

Landscape Features	Soil Capability And Moisture Regime	Target Ecosite Phase	Tree Species[a] (Total Density of 1800 - 2200 Stems / ha)	Shrub Species[a] (Total Density of 500 - 700 Stems /ha)
Tailings Sand, Crests	Soil Class 4, Xeric, Subxeric	a1 Lichen, jack pine	Jack Pine	Blueberry, Bearberry, Green Alder
Tailings Sand Slope, South Aspect	Soil Class 4-3, Subxeric, Submesic	b1 Blueberry, jack pine-aspen	Jack Pine Aspen White Spruce	Blueberry, Bearberry, Labrador tea, Green Alder
Tailings Sand Slope, North Aspect	Soil Class 3-2, Subxeric, Submesic	b2 Blueberry, aspen (white birch)	Aspen White Birch White Spruce	Blueberry, Bearberry, Labrador tea, Green Alder
		b3 Blueberry, aspen-white spruce	Aspen White Spruce White Birch	Blueberry, Bearberry, Labrador tea, Green Alder
		b4 Blueberry, white spruce-jack pine	White Spruce Jack Pine	Blueberry, Bearberry, Labrador tea, Green Alder
Overburden, Low Organic	Soil Class 3, Mesic, Submesic	c1 Labrador tea (mesic), jack pine-black spruce	Jack Pine Black Spruce	Labrador tea, Green Alder, Bog cranberry, Blueberry
Overburden, South Aspect	Soil Class 3-2, Mesic	d1 Low-bush cranberry, aspen	Aspen White Spruce Balsam Poplar White Birch	Low-bush Cranberry, Canada Buffalo-berry, Saskatoon, Green Alder, Rose, Raspberry
Overburden, North Aspect	Soil Class 3-2, Mesic	d2 Low-bush cranberry, aspen-white spruce	Aspen White Spruce Balsam Poplar White Birch	Low-bush Cranberry, Canada Buffalo-berry, Saskatoon, Green Alder, Rose, Raspberry
Overburden, North Aspect	Soil Class 3-2, Mesic, Subhygric	d3 Low-bush cranberry, white spruce	White Spruce Aspen Balsam Poplar White Birch	Low-bush Cranberry, Canada Buffalo-berry, Saskatoon, Green Alder, Rose, Raspberry
Near Level Overburden or Tailings Sand	Soil Class 3-2, Subhygric, Mesic	e1 Dogwood, balsam-aspen	Aspen Balsam Poplar White Spruce White Birch	Dogwood, Low-bush Cranberry, Raspberry, Green Alder, Rose
Near Level Overburden or Tailings Sand	Soil Class 3-2-1, Subhygric, Mesic	e2 Dogwood, balsam-white spruce	White Spruce Aspen Balsam Poplar White Birch	Dogwood, Low-bush Cranberry, Raspberry, Green Alder, Rose
		e3 Dogwood, white spruce	White Spruce Aspen Balsam Poplar White Birch	Dogwood, Low-bush Cranberry, Raspberry, Green Alder, Rose
Near Level Overburden or Tailings Sand, Lower Slope Position	Soil Class 2-1, Subhygric	f1 Horsetail, balsam-aspen	Balsam Poplar Aspen Birch White Spruce	Rose, Green Alder, Dogwood, Raspberry, Low-bush Cranberry
		f2 Horsetail, balsam-white spruce	White Spruce Aspen Balsam Poplar Birch	Rose, Dogwood, Low-bush Cranberry
		f3 Horsetail white spruce	White Spruce	Rose, Low-bush Cranberry

[a] In general, species are listed in order of dominance to be planted in the target ecosite phase.

Seeding and Seed Source Considerations

A focus of the reclamation program is to encourage the invasion by native vegetation and establish woody seedlings. Selection of appropriate seed mixtures, application methods and application rates can impact plant species diversity and seedling survival on the reclamation areas. To enhance seedling survival and native species invasion, a barley nurse crop is used on the reclamation sites. Sites are not seeded with grasses, as grasses compete with tree seedlings for nutrients and moisture.

The seed source or tree seed variety used in seeding or planting programs must be registered with the Alberta Tree Improvement and Seed Centre and follow seed provenance rules, as the seed source or variety must be specified on the Silviculture Records Management System (SRMS) or an equivalent system for long-term documentation.

The use of plant varieties with local seed provenance has two major advantages:

- Reduces the risk of maladaptation in the regenerated forest, and
- Maintains genetic integrity and evolutionary potential of local forest tree populations.

See Appendix I for further discussion of seed sourcing and seed zones.

Plant Variety Use Consideration

Specifically developed, locally adapted genetic varieties of plants may provide some advantage in land reclamation depending on traits selected. These traits may include superior growth and survival, climatic and pest hardiness, soil salinity tolerance, and others. Deployment of selected varieties requires further consideration of the impact on genetic diversity and ecosystem adaptations.

Exotic tree species, non-native hybrid varieties and clonal materials are not to be deployed in operational practice (see Appendix D), but research testing using these species can be conducted to obtain scientific information and experience. Research testing should be defined and research trials catalogued. Certain types of research trials may require referral, review and approval by Alberta Environmental Protection, Land and Forest Service.

3.3 SUMMARY OF UNCERTAINTIES AND DATA GAPS IN ECOSITE RECLAMATION AND FUTURE RESEARCH

There are several areas of reclamation that still need to be researched. These include:

- Vegetation productivity (site index) on reclaimed soils needs to be measured and compared to vegetation productivity on natural soils,
- The relationship between soil capability classes and vegetation productivity (site index) needs to be identified through monitoring programs,
- It is uncertain whether all plant species recommended as starter species can be propagated on reconstructed soils (Table 3.4). Future propagation of additional plant species, such as those in Appendix H, needs to be studied,
- The survival and vitality of plant species moved through direct placement from various ecosystems to reclamation sites supporting different subsoils needs to be examined,
- The potential effects of elevated pH levels in reconstructed soils on plant growth are not known and need to be studied,
- The feasibility of using mineral soil through direct placement to develop upland ecosystems needs to be examined,
- The effectiveness of covering and reclaiming saline/sodic materials needs to be studied,
- The feasibility of continuing the use of exotic plant species in reclamation needs to be examined,
- Methods to measure biodiversity need to be developed,
- Draft seed zone maps for the oil sands area were developed with the intention of covering both woody and other vascular plants but may need to be further refined to determine their suitability for other vascular plants,
- The feasibility of re-establishing ecosystems on CT needs to be researched,
- The feasibility of applying sulphur to reduce soil pH and sodicity needs to be examined,
- Methods to enhance the establishment of native understorey species to achieve greater biodiversity than is possible through seeding/planting need to be developed,

- The biology and productivity of reclaimed soils should be examined. Mycorrhizae, nutrient cycling and sustainability of peat-mineral mix amendments to ensure that the "living" components of the soil system are functioning effectively and in balance should be the focus of the research,
- Seed sources for species that provide good timber/fibre production need to be improved,
- Essential ecosystem functions and plant species required to accomplish these functions need to be determined, and
- The ability to create ecosites d (low-bush cranberry) and e (dogwood) without adding clay is uncertain. The sustainability of the ecosites needs to be studied.

Further research requirements will be identified based on results of the recommended monitoring programs discussed in Section 6.0.

4. DESIGN CRITERIA FOR COMMERCIAL FORESTS

4.1 DEFINITION OF, AND CONDITIONS TO SUPPORT COMMERCIAL FOREST

In this document commercial forest is defined as:

- Land with a soil capability class of 1 to 3 which can support sustainable forest growth. Forests can be grown on class 4 soils, however these are not considered commercial,
- Lands stocked with native tree species which may include white spruce, black spruce, jack pine, aspen poplar, balsam poplar, white birch and/or larch, and
- Forest stands not limited by operating restrictions such as stream buffers, potential recreation lake buffers, stand size, arrangement or accessibility. These operating restrictions are discussed in detail in the following section.

In the context of reclamation, a commercial forest also includes established seedlings that can be reasonably expected to become an operable stand of acceptable trees. Operability is controlled by the following factors:

- Location must not be within a watercourse or wildlife protection buffer,
- Maximum permissible slopes are 45% (20% on tailings sand) and preferred slopes $\leq$ 30%,
- The minimum stand size must be greater than 4 ha, and
- Volume at maturity must provide greater than 50 m^3 per ha of acceptable trees (i.e., trees that provide adequate volumes of timber at maturity).

Acceptable trees are defined to include:

- Species as defined in the "Alberta Regeneration Survey Manual" (Alberta Environmental Protection 1994b):
  - established seedlings for an area harvested primarily for coniferous timber, and acceptable established seedlings for an area harvested primarily for deciduous timber,
- Minimum size at maturity as defined in the "Timber Harvest Planning and Operating Ground Rules" (Alberta Environmental Protection 1994a), is 15 cm diameter at the butt and with a useable length of 3.66 m to a 10 cm top diameter, and

- Suitable quality meaning less than 50% cull as defined in the Provincial Scaling Regulation.

4.1.1 Operating Restriction Guidelines

A number of characteristics limit the operability of a forest stand. Although these limitations do not preclude the development of forest stands, the resulting forest should be designated non-commercial for timber production. For complete design guidelines, refer to the "Timber Harvest Planning and Operating Ground Rules" (Alberta Environmental Protection 1994a), that are updated periodically.

4.1.1.1 Terrain Considerations

Slopes up to 45% can support commercial forest, although harvesting is normally conducted on slopes of 30% or less. Slopes over 30% and more than 50 m long are considered severe logging areas (Alberta Environmental Protection 1996a) and therefore reclaimed landscape on slopes between 30 and 45% that will be considered for commercial forest will be limited to an area equivalent to what existed prior to disturbance.

Furthermore, because of the erosive nature of the tailings sands, slopes up to only 20% are considered suitable for commercial forest. On overburden, slopes greater than 20% for distances greater than 200 m require special design considerations to ensure access and log decking capability. This includes requirements for a 40 m wide area of less than 5% cross slope and less than 8% adverse grade or 12% favorable grade for road and deck placement.

In addition to the terrain considerations outlined above, reclamation planning must also consider stream and watershed protection requirements, access limitations and harvesting constraints. Vegetated watercourse buffers are required on all streams and lakes. The characteristics of the vegetated buffers are based on the size and uses of the watershed. These buffers are not considered part of the commercial forest in the reclaimed landscape. Current watershed guidelines are provided in Appendix I. When slopes greater than 20% are adjacent to, or overlap with the vegetated buffer, the slopes becomes inoperable and therefore are not considered as part of the commercial forest land base.

Landscape capability classes 1, 2 and 3 are suitable for commercial forestry, provided slopes comply with regulatory requirements. To replace an equivalent commercial forest land base, landscape capability classes (on an area basis) must be maintained at pre-disturbance levels. However, improvements in capability classes are acceptable.

4.1.1.2 Stand Characteristics

The minimum stand size for operability is 4 ha. Stands must be at least 100 m wide, with a preferred width of 400 m.

Seventy percent of the spruce stands should be over 10 ha, with a minimum average size of 16 ha. Eighty percent of the pine and aspen stands should be over 20 ha, with a minimum average size of 40 ha. These characteristics are similar to those of natural occurring spruce, pine and aspen stands (Table 4.1).

Table 4.1
Stand Characteristics

Tree Species	Stand Width (Meters)		Stand Sizes (Hectares)			
			Minimum	Natural State		Minimum Average
	Minimum	Preferred		%	Greater than	
White Spruce	100	400	4	70%	10	16
Jack Pine	100	400	4	80%	20	40
Aspen	100	400	4	80%	20	40

For calculation of operability standards, stands that are adjacent and have common merchantability characteristics may be considered as one unit.

Natural forests have irregular shapes. However, to be able to harvest a finger, the skidder must be able to turn the trees which requires a width of 40 m. Narrower extensions of forests into non-commercial stands are currently not operable.

4.2 ECOSITES THAT MEET THE DEFINITION OF A COMMERCIAL FOREST

The target reclaimed ecosites considered to be commercially suitable in the oil sands region are: b (blueberry), c (Labrador tea-mesic), d (low-bush cranberry), e (dogwood) and f (horsetail). Ecosite a (lichen) is too dry, and ecosites g (Labrador tea-subhydric) to l (marsh) are too wet for commercial forest purposes. In natural areas, ecosites b to f are considered to have commercial potential.

4.3 METHODS TO MAINTAIN GUIDING PRINCIPLES

The maintenance of the guiding principles (Section 2.1) will not be difficult in reclamation areas that are designated to provide commercial forest.

The prescriptions should include a range of stand types and sizes characteristic to the region. This is required to adequately address the site requirements of the commercial tree species. Black spruce should be prescribed surrounding and in wet imperfectly drained areas, white spruce on lower slope and hygric sites, mixedwood on mid-slope moisture regimes and jack pine stands on xeric sites. In the mixedwoods, the conifer component should trend from white spruce to jack pine as the site trends to drier moisture regimes.

The establishment of these prescriptions must be based on the ecosite classification for northern Alberta (the ecosite principle). During establishment, the planting of herbaceous and shrub layer species, similar to those found in natural ecosites, will promote stand biodiversity.

The sustainability and productivity of the commercial forests is a function of the forest and soils development and are expected to be met by natural processes. Should results of the forest and soil productivity monitoring program (Section 6.1.2) show declining productivity, the causes will need to be investigated. Remediation methods that will be implemented to improve productivity will depend on the capability levels and the current technology.

The commercial forest monitoring system (Section 6.1) will provide ongoing information for periodic revision of this manual and the practices being used to establish commercial forests on reclaimed oil sands leases.

5. DESIGN CRITERIA FOR ASSOCIATED LAND USE - WILDLIFE HABITAT

Ecological factors that directly influence the suitability of terrestrial habitat for wildlife include vegetation types and landscape factors, such as topography, slope, aspect, and the size and interspersion patterns of ecosite phases/plant communities.

Good habitat provides a combination of high quality food and cover for species of wildlife. Landscape diversity and ecosite phase or plant community diversity are fundamental factors required to support a sustainable forest and wildlife community. Factors of importance to an animal's survival may be specific and narrow, such as a reliance on a particular type of plant for food, or the presence of minimum diameter escape trees. However, for most wildlife species, habitat suitability is governed by broader biological and physical characteristics such as shrub or tree canopy cover, slope and topographic characteristics. Although food and cover requirements can be provided to a wildlife species by one vegetation community, many animals are dependent on a variety of communities to meet their annual or seasonal life history requirements. Therefore, the interspersion pattern of different community types is an important component of habitat quality for a variety of wildlife species.

Habitat can be re-established based on either a coarse or fine filter approach. The main objective of the coarse filter approach is to re-establish the same types of vegetation communities in the same abundance and dispersion patterns, as existed prior to disturbance. This is pursued with the expectation that wildlife populations will return to the reclaimed sites in the same composition and abundance as existed prior to disturbance. Re-establishment of a range of ecosites is an example of the coarse filter approach.

The objective of the fine filter approach is to reclaim an area to provide the specific biophysical habitat requirements of indicator wildlife species. Although all vegetation types provide some value or suitability for several species of wildlife, each group of species prefers certain ecological factors that better meet their requirements. Therefore, the groups of wildlife species for which habitat establishment is to be targeted need to be identified before lands being reclaimed can be designed to support wildlife species. Then, the ecological factors that provide the most suitable habitat for the targeted wildlife can be documented in the design criteria.

The fine filter approach to preparing design criteria for wildlife habitat to be established on reclaimed landscapes, was broken into four steps:

- Identify the target wildlife species (Section 5.1.1),
- Identify the habitat requirements of these representative target wildlife species (Appendix J),

- Identify the ecosites and landscape components that meet the habitat needs of the targeted wildlife species (Section 5.2 and Appendix J), and

- Identify the methods that could be used to reclaim disturbed areas to establish habitat for these species (Section 5.3).

5.1 DEFINITION OF AND CONDITIONS TO SUPPORT WILDLIFE HABITAT

5.1.1 Target Wildlife Species and Habitat Requirements

Over 41 species of mammals, 188 species of birds, 4 species of amphibians and 1 species of reptile potentially inhabit the oil sands region, either on a seasonal or year-round basis. A summary of wildlife populations that occur in the oil sands region is presented in Appendix J. Several wildlife species that represent niche associations (species that have similar habitat requirements) were selected in order to define design criteria for reclaimed landscapes for wildlife. They were selected based on ecological importance, niche representativeness and abundance, and resource use value (Appendix J). Generally these target wildlife species are of ecological or socio-economic importance, should be herbivores or omnivores rather than carnivores (as the abundance and distribution of most carnivores are influenced to a greater degree by prey availability than by habitat parameters), should have relatively well understood habitat requirements, and should adequately represent the habitat requirements of a variety of other species.

The representative target species for terrestrial habitats are:

- Moose,
- Black Bear,
- Snowshoe Hare,
- Red Squirrel,
- Ruffed Grouse,
- Fisher,
- Great Gray Owl,
- Passerines (Cape May warbler, ovenbird, warbling vireo), and
- Microtines (red-backed vole and deer mouse).

Justification for selecting these wildlife species is presented in Appendix J.

Table 5.1
Factors Used to Select Target Wildlife Species

Criteria For Selecting Wildlife Species	Description
Ecological Importance	The degree to which wildlife species is involved in or contributes to nutrient cycling, the food chain or physical maintenance of ecological communities.
Niche Representativeness and Abundance	The degree to which the species represent the habitat requirements of a variety of other wildlife species, and that they are relatively abundant in the region.
Resource Value	The value of species for subsistence and recreational hunting and trapping, and non-consumption use (wildlife viewing, photography or aesthetic value).

The general habitat requirements of the target wildlife species are presented in Appendix J.

5.2 ECOSITES AND LANDSCAPES THAT MEET THE DEFINITION OF WILDLIFE HABITAT

The ecosites that can be supported by the landscape, drainage and soil characteristics of the reclaimed oil sands leases have been discussed in Section 3.1 and include the following ecosites: a (lichen), b (blueberry), c (Labrador tea-mesic), d (low bush cranberry), e (dogwood), f (horsetail), g (Labrador tea - submesic), and h (Labrador tea/horsetail), i (bog), j (poor fen), k (rich fen), and l (marsh).

The ecosites and landscape patterns on reclaimed oil sands leases that would meet the habitat requirements of the target wildlife species are outlined in Appendix J.

5.3 MAINTAINING GUIDING PRINCIPLES AND RECLAIMING DISTURBED AREAS AS WILDLIFE HABITAT

Several approaches to the material handling, water management and revegetation would increase the topographic and habitat diversity, water availability and shelter and forage quality available for wildlife species. An undulating landscape with a diversity of slopes, aspects, elevations and moisture holding capabilities, slightly more rolling than that designed for reforestation, and with a mosaic of vegetation types with a variety of lakes and ponds is recommended for wildlife habitat. Both landscape diversity and plant community biodiversity need to be addressed when designing habitat for wildlife. Palatable plant species, both herbaceous and woody-stemmed should be included in starter plant species mixes (Table J.1, Appendix J) outlines the palatability of plant

species that occur in the oil sands region). The addition of slash and deadfall will improve the quality of habitat of the reclaimed landscape for some wildlife species.

Each plant community will provide habitat with varying degrees of wildlife capability for different species. Wildlife utilization of the reclaimed areas will increase as the food and shelter becomes available with the maturing vegetation on the reclamation sites. Some mammalian species are routinely observed on the reclamation sites, while others frequently utilize the fringe areas adjacent to undisturbed stands. Stands will increasingly be utilized by these latter animals as they mature. For example, lynx, fisher and red squirrels prefer climax coniferous forest with a high degree of crown closure, numerous deadfalls and a few openings where shrubs can develop. Wildlife utilization of reclaimed areas will also vary by season.

5.3.1 Landscape Diversity

Wildlife species that exist in forest ecosystems vary widely in their requirements for space. Territory or home range sizes vary from less than one hectare for small animals such as red-backed voles and many songbird species to hundreds of square kilometers for wide ranging species such as wolves and bears. A forest must be spatially diverse to support a high diversity of wildlife, although the degree of diversity required varies from species to species. Generally, most species that occupy extensive ranges tend to be habitat generalists; that is, they use a diversity of preferred habitat types. The most difficult species to manage in a reclamation plan are habitat specialists, those species requiring relatively uniform environments or specific habitat conditions, or single habitat types. Most habitat specialists have relatively small home ranges, although some forest interior species require larger blocks of habitat.

Depending on the wildlife target species selected, a mosaic of plant community types will need to be established within the reclaimed landscape to meet the habitat requirements of wildlife. The size, shape and dispersion patterns of the plant communities are referred to as the landscape diversity. Using the coarse filter approach, the mosaic of plant communities (number of communities, size, shape and dispersion) established should be similar to those in the predisturbed landscape. Using the fine filter approach, the size, shape, and dispersion of plant communities will be determined by the landscape requirements of the target wildlife species. Various sizes of habitat blocks required by the potential target wildlife species have been presented in Appendix J.

The landscape and resulting habitats can be diversified in two ways:

- First, overburden dump and dyke walls can be recontoured to provide a complex topography of slopes and aspects. Recontouring can include micro-scale modifications or macro-scale modifications. Micro-scale modifications can create microsites. Differences in aspect, soil moisture regime and water or snow accumulation between micro-sites will result in improved vegetation

diversity. This will in turn benefit wildlife by providing a greater diversity of browse and forage species. An example of a recontoured dump (macro-scale modifications) designed to provide good ungulate habitat is described by Proctor *et al.* (1983). It is crescent shaped with the outer circumference consisting of south-facing slopes with grass for winter range development, and with trees on the north side of the structure. Snow fences on south- and west-facing slopes can help retain moisture and facilitate shrub establishment which provide shelter on winter range.

- Second, water impoundments can be developed throughout the reclaimed site. These features would provide water sources and escape cover with additional tree and shrub growth along the edges.

The maintenance of diversity is also dependent on the maintenance of wildlife movement corridors between habitat patches. These corridors meet the needs of wildlife in two ways. The first is for species that make periodic movements between different habitat types required for breeding, birthing, feeding, cover and roosting. Second, such movements may range from annual migrations of ungulates between winter and summer ranges, to daily movements of birds between feeding and roosting sites. Such movements allow for gene flow between populations and recolonization of areas following local extinctions.

It is difficult to specify criteria for the design of movement corridors for wildlife. Requirements will vary between species and because of factors such as vegetation density, topography and proximity to disturbance factors. Furthermore, there has only been limited research conducted to determine the design and utility of movement corridors. Based on the literature that does exist, forested corridors 100-500 m wide are probably required to effectively support seasonal movements of large ungulates such as moose. The establishment of effective movement corridors in the oil sands region may, however, be dependent on the collection of baseline information to identify key movement corridors and their characteristics. Such studies should also examine the role natural corridors, such as river valleys, play in supporting local and regional wildlife movement patterns.

5.3.2 Plant Community Biodiversity

Plant community biodiversity refers to the structural diversity (number of vegetation layers e.g., herbaceous, shrubs, trees) and plant diversity (number of species and their abundance) within plant communities that provide habitat.

The establishment of more structurally complex and productive wildlife habitats on reclaimed areas can be assisted by planting a diverse mixture of native plant species of different life forms (e.g., grasses, forbs, shrubs and trees). Selected species should

include some of the more important wildlife food plants (Appendix J). The structure and composition of the initially established communities will be simplistic in comparison with the natural undisturbed ecosystems. The newly reclaimed communities will lack the "within habitat" diversity that characterizes natural ecosystems. Over the long-term, however, additional native species should recolonize reclaimed areas, resulting in an increase in plant and animal diversity. As time passes, structural diversity will also be created through natural succession and through the succession of forest communities after natural disturbance such as fire. For relatively complex ecosystems it may take hundreds of years before recolonization is complete and the full complement of native species are restored.

The rate of recolonization of reclaimed landscapes by native plant species can be increased by retaining refugia or "islands" of intact natural ecosystems within the larger development area. This practice can be achieved by leaving intact, areas within the development footprint that are not required for excavation or facilities construction. Where possible, native habitat corridors should be maintained to connect extensive reclaimed areas with undisturbed habitat. These connections would accelerate recolonization of reclaimed areas by wildlife and would enhance habitat interspersion. These refugia would serve as sources of seed for native plant establishment and would assist in speeding recolonization of reclaimed areas by amphibians, birds, small mammals and the hundreds of species of invertebrates that exist in forest soils.

Another method of increasing the rate of recolonization is to transplant patches of soil and vegetation from natural ecosystems to reclamation areas. A mixture of peat and underlying surficial materials, spread over reclamation areas as a soil amendment, contains seeds and roots of many native plant species, some of which become established on the reclaimed site. Placing this material in "islands" across extensive reclamation areas is expected to facilitate the recovery of natural biodiversity.

5.3.3 Starter Plant Species

Two approaches to establishing plants are currently used on oil sands leases:

- A layer of peat-mineral mix is applied to the reclamation sites and root fragments and seed within this amendment become established. The result of this volunteer growth is that reclamation sites are soon covered with a mix of vegetation, more closely related to a cut-over area than a mining disturbance, and

- Specific woody stemmed plant species are selected for out-planting to establish plant communities during the reclamation phase (Table 3.4). Many of the starter species are quite palatable for wildlife (Appendix J). For example, favoured browse species for moose include saskatoon, willow, low-bush cranberry,

aspen, red-osier dogwood, white (paper) birch, balsam poplar, pincherry and chokecherry. Most of these species are included as part of the revegetation program, while the remainder are expected to invade naturally.

5.3.4 Slash and Deadfall

Habitat in boreal forests is provided not just by living vegetation but also by the dead and decaying vegetation components. Many species depend on snags and fallen logs for cover, as nesting or denning sites, drumming sites and as feeding substrates. Some of these wildlife benefits could be achieved by distributing logs and slash across areas undergoing reclamation. This practice would also result in nutrient enrichment of these reclamation areas. Decomposing slash provides a moist seedbed, and serves as sources of mycorrhizal fungi. Deadfall is also an important habitat element for small mammals, such as red-backed voles, which consume the fruiting bodies of the fungi and serve as agents of dispersion for spores.

6. MONITORING PROGRAMS

Monitoring programs are necessary to determine if the land use objectives have been achieved. For each of the two land use objectives, commercial forest and wildlife habitat, the benchmarks to assess whether the reclamation approach has been successful has been identified, and the detailed monitoring program has been described. Monitoring options have also been presented for diversity/biodiversity.

6.1 MONITORING PROGRAM TO VERIFY ACHIEVEMENT OF COMMERCIAL FOREST OBJECTIVES

The commercial forest monitoring program has two purposes. The first purpose is to demonstrate compliance with the conditions of the approval to operate the oil sands facility. The second purpose is to provide information to improve continued oil sands reclamation activities.

Two monitoring programs are recommended to ensure that a commercial forest is being established: a program to verify the establishment of tree seedlings to meet compliance regulations and a program to verify the establishment of a productivity equivalent to or better than a natural forest. The latter long-term productivity of the forest is dependent on the soils and other site characteristics.

6.1.1 Compliance - Establishment of Seedlings

The establishment of a forest is considered complete when sufficient acceptable growing stock is on the site at 14 years after planting. Acceptable growing stock is described in the Alberta Regeneration Survey Manual (Alberta Environmental Protection 1994b).

6.1.1.1 Benchmark - Reforestation Regulations

The Province of Alberta administers the forests within the Green Zone of Alberta under the authority of the Forests Act. The Timber Management Regulation (passed under the authority of the Forests Act) specifies the Alberta Regeneration Survey Manual (Alberta Environmental Protection 1994b) as the document describing reforestation standards. This manual is modified periodically to ensure currency with reforestation technology. The process generally involves negotiations between the province and representatives of the forest industry.

It is important to note that an equivalent amount of conifer, mixedwood and deciduous commercial forest is required in the reclaimed landscape as the predisturbance condition. The productive capability of these forests (appropriate seedling height at a given age) should meet or exceed predisturbance conditions as outlined in Table 6.1 and Appendix B.

Table 6.1
Yield Curve for Commercial Forest Ecosites

Ecosite	Ecosite Phase	Yield Class	Site
a – lichen	(a1) jack pine	24F - Coniferous jack pine	Fair
b – blueberry	(b1) jack pine-aspen	18M - Coniferous/Deciduous jack pine	Medium
	(b2) aspen (white birch)	2M - Deciduous	Medium
	(b3) aspen-white spruce	9M - Deciduous/Coniferous white spruce	Medium
	(b4) white spruce-jack pine	21M - Coniferous white spruce	Medium
c – Labrador tea mesic	(c1) jack pine-black spruce	25F - Coniferous jack pine	Fair
d - low-bush cranberry	(d1) aspen	2M - Deciduous	Medium
	(d2) aspen-white spruce	9M - Deciduous/Coniferous white spruce	Medium
	(d3) white spruce	21M - Coniferous white spruce	Medium
e – dogwood	(e1) balsam poplar	2G - Deciduous	Good
	(e2) balsam poplar-white spruce	9G - Deciduous/Coniferous white spruce	Good
	(e3) white spruce	21G - Coniferous white spruce	Good
f – horsetail	(f1) balsam poplar-aspen	2G - Deciduous	Good
	(f2) balsam poplar-white spruce	9G - Deciduous/Coniferous white spruce	Good
	(f3) white spruce	21G - Coniferous white spruce	Good
g - Labrador tea-subhygric	(g1) black spruce-jack pine	23F - Coniferous black spruce	Fair
h - Labrador tea/horsetail	(h1) white spruce-black spruce	21M - Coniferous white spruce	Medium

The benchmark to be applied will be the standards defined in the Alberta Regeneration Survey Manual (Alberta Environmental Protection 1994b) in place at the time of planting the reclaimed site.

Currently, there are three acceptable standards, all of which require 80% of the plots in a standard survey to be stocked with an acceptable tree(s) to a minimum height standard. The three standards are conifer, mixedwood or deciduous. The conifer standard requires a minimum 70% stocking with conifer (white spruce, jack pine or black spruce) seedlings and 10% conditional seedlings (aspen, balsam poplar, birch or fir). The conifer seedling may not have another tree or shrub seedling within 1 meter that is taller than the crop trees. The mixedwood standard reduces the conifer requirements to 50% and the deciduous standard does not require a conifer component.

The choice of standard in the Alberta Regeneration Survey Manual is based on the stand occupying the site prior to harvest. This provides a silviculture prescription that is appropriate for the ecosite. On reclaimed oil sands sites the important characteristics that define the choice of standard are slope position, aspect and moisture regime. Drier sites (top of slope and south facing) tend to be more suitable for jack pine with a trend to aspen, mixedwood, white spruce and eventually black spruce as the moisture regime increases to flat sites with impaired drainage. It is important to note that an equivalent amount of conifer, mixedwood, and deciduous commercial forest, at an equivalent productive capability (fiber volumes as per Table 6.1 and Appendix B) is required in the reclaimed landscape as the predisturbance condition.

6.1.1.2 Forest Establishment Program Design

The forest establishment program is to follow the reforestation standards for all sites designated for commercial forest production. Each unit with a uniform silviculture prescription should be considered a stand. The program requires each stand to meet establishment standards by five to eight years after the reclamation date and meet the performance standard prior to fourteen years after the reclamation date. The reclamation date is the first day of May immediately following the tree planting phase of reclamation.

The Alberta Regeneration Survey Manual, Section 3, details the field survey procedures to be used including number of plots, layout, data collection and mapping. Sections 4 and 5 of the manual outline office compilation and survey submission procedures. Tally cards can be obtained from the local Land and Forest Service office.

The standard that is to be applied to an individual stand will be the legislated standard at the time of reclamation and will not change after the start of reclamation activities, regardless of changes in the Alberta Regeneration Survey Manual that may occur from time to time.

The deciduous regeneration standards, subject to amendment from time to time, will apply to reclaimed oil sands sites reforested for deciduous landbase. The 1997 standard requires an average density of 7000 deciduous stems at the establishment survey (3 to 5 years), which is not readily achievable on most reclaimed oil sands sites. Therefore, it is recognized that most of the deciduous landbase will be subject to a performance survey (10 to 14 years) where there is no density requirement but subject to the 80% stocking and the associated height requirements.

6.1.2 Long-term Forest Productivity

The forest establishment program includes surveys up to 14 years on every stand but does not continue past the 14 year performance survey unless the request for a Reclamation Certificate is delayed. The long-term measurement of productivity will be completed by measuring forest growth over time and the changes in the soil capability. The forest establishment program will be based on target ecosites (not individual stands). Due to uncertainties related to the productivity of forests on reconstructed soils, additional information is required including:

- Assessment of crop tree health describing any symptoms of nutrient deficiency, and
- Measurement of the last 3 years annual height increments to determine if growth is comparable to that predicted by the stand yield curves or growth intercept curves on corresponding soil capability classes.

In order to confirm or refine the soil capability and forest productivity relationship, as modeled by the soil capability classification approach, it is necessary to have ongoing monitoring of soils and forest growth at the same plots. Such comparisons are required to properly characterize baseline conditions as well. Superimposing forest inventory polygons on soil polygons to establish forest-soil relationships provides a less accurate comparison.

Polygons to sample forest productivity will be randomly selected permanent sampling plots measured every 5 years.

6.1.2.1 Benchmark - Mean Annual Increment and Site Indices

The forest productivity program benchmarks will be the yield curves developed by Alberta-Pacific Forest Industries (Timberline Forest Inventory Consultants 1997). These yield curves are reviewed periodically (approximately every 10 years) and adjusted according to additional data collected during the period. Table 6.1 summarizes the appropriate yield curves for each phase of the commercial forest ecosites. The yield curves provide a variable Mean Annual Increment (MAI) and an expected volume per hectare based on the age of the stand. These quantities provide the baseline for stand productivity measurement.

6.1.2.2 Benchmark - Measurement of Soil Capability

The soil monitoring program is intended to be integrated with the forest productivity monitoring, hence soil sampling sites should be in the immediate vicinity of the permanent forest plots and should be sampled at the same frequency. When plots are being established, it is recommended that the soils be inspected to ensure they match the design profile and are representative of the reclaimed area. Table 6.2 displays the forest and soil monitoring requirements at various stages of the reclamation process.

6.1.2.3 Long-term Forest Productivity Program Design

The Northern Interior Vegetation Management (NIVMA) Sampling Protocol (Szauer 1995) will provide the basic plot design for measurement of forest productivity. This protocol may require slight modification for oil sands reclamation. The design will include a permanent plot with remeasurement every 5 years for the first 15 years after reclamation and every 10 years thereafter. This survey system will be able, or could be modified to, provide information for other monitoring programs such as wildlife habitat and biodiversity.

There should be three plots created for the first 300 ha of each reclamation prescription. Every additional 100 ha of the same reclamation prescription should have another plot created. Continued use of the same reclamation prescription for subsequent years should continue to add to the data collection.

Table 6.2
Forest and Soil Monitoring of Benchmark Sites

	MAI and Site Index	Soil Capability[a]	Nutrient Levels[b]	Other[c]
Baseline - Year Zero	✓	✓	✓	✓
5 year	✓		✓	✓
10 year	✓	✓	✓	✓
15 year	✓		✓	✓
25 year	v	✓	✓	✓
10 year increments	✓		✓	✓

Sampling Protocol

a Standard profile and site description at representative site outside edge of vegetation plot.

b,c For LFH take minimum of 10 subsamples to make 1 sample, along outside edge of vegetation plot; for TS (topsoil) and US (upper subsoil) take minimum of 5 subsamples each to make 1 sample each, along outside edge of vegetation plot; TS should be about 10-20 cm thick and US should be below TS to about 50 cm. Sample by horizon rather than by depth, and record depths at each subsample point.

Laboratory

(a) pH (H_2O), Electrical Conductivity, SAR, Organic Carbon (OC) content, bulk density, (texture only first time) in TS, US, LS.

(b) Total N, P, K. and S; OC, pH ($CaCl_2$) in TS and US, and LFH when one develops.

(c) Bitumen content in TS and US on overburden materials. Optional mychorrizal studies in TS and US (to be determined).

Frequency

Match forest productivity monitoring; that is, 3 plots for first 300 ha of any reclamation prescription, plus an additional plot for every additional 100 ha of the same reclamation prescription.

6.2 MONITORING PROGRAM TO VERIFY ACHIEVEMENT OF WILDLIFE HABITAT OBJECTIVES

The wildlife habitat monitoring program will provide ongoing information for periodic revisions of this document and the practices being used to establish wildlife habitat on reclaimed oil sands leases.

As noted in Section 5, habitat can be re-established based on either a coarse filter or fine filter approach, and both approaches have been discussed in this document.

A monitoring program to verify the achievement of wildlife habitat objectives using the coarse filter approach would need to document whether the same types, abundance, sizes (patches) and distribution patterns of plant communities as existed in the predisturbance landscape have been re-established in the reclaimed landscape. This is the benchmark for the monitoring program based on the coarse filter approach. The landscape level monitoring program for biodiversity outlined in Section 6.3, documents changes in ecosite phase communities. Therefore, data from this program could be evaluated to assess whether habitat capability has been generally replaced for all wildlife species. The monitoring program should also be designed to assess whether the design criteria for movement corridors in specific areas of the lease have been achieved.

A monitoring program to verify the achievement of wildlife habitat objectives using the fine filter approach would need to document whether the biophysical habitat requirements of several wildlife species have been provided in the reclaimed landscape. The food, cover, landscape and special habitat requirements of twelve indicator target wildlife species that represent the habitat requirements of a broad range of species in the region are outlined in Appendix J.3.0. These habitat requirements are the benchmarks for the monitoring program based on the fine filter approach. Appendix J.4.0 indicates which ecosite phases provide high and moderate suitability habitat for these species.

Habitat Suitability Index (HSI) models and Habitat Evaluation Procedures (HEP) developed by the US Fish and Wildlife Service have been widely applied to assess wildlife habitat quality and could be readily applied to evaluate the suitability of reclaimed landscapes for wildlife. An HSI model uses the physical and biological attributes of a particular habitat to calculate an index of habitat suitability that is assumed to be proportional to the habitat's carrying capacity for a species. HSI values for a particular habitat range between 0 and 1; a habitat with an HSI of 1 is considered to have optimal habitat, while an HSI of 0 indicates that the habitat has no value for the wildlife species in question. The Habitat Evaluation Procedure combines measures of habitat quality in terms of numbers of Habitat Units (HU) available in an area, where HU = HSIxArea.

The monitoring program should be designed to collect data on the biophysical parameters in the models. Initially, these models could be run in the planning stages to determine whether planned landscapes would contain suitable habitat for wildlife species over time. As vegetation communities are established, the models should be run using actual field measurements to determine whether there is a need for further refinement of reclamation plans.

6.3 DIVERSITY/BIODIVERSITY MEASUREMENT OPTIONS

The objective of the diversity/biodiversity monitoring program will be to compare diversity on reclaimed lands to the range of natural variability. It is important that diversity in reclaimed lands approach the natural range of variation in the predisturbed landscape. Long-term control sites in natural vegetation types are needed to provide baseline data for comparison with reclaimed lands because change to the environment due to climate, industrial development, air pollution and wildfire can influence development of natural vegetative communities. The range of diversity should be determined across the scope of landscape, plant community and within species levels (Figure 2.1).

Program design features for diversity/biodiversity monitoring include:

- The use of a detailed statistical power analysis to determine the overall number of sample sites required, and
- Sampling the sites beginning at year zero and then sampling every 5 to 10 years.

Parameters that should be measured during the monitoring programs are listed below:

- **Landscape Level:**
    - Number, range of sizes and shapes, spatial distribution of ecosite phases, communities, and number of seral stages,
    - Variability and distribution pattern (size, shape and dispersion) of slope classes, aspect, and reclamation substrates,
    - Variability and distribution of drainage patterns,
    - Topographical diversity, and
    - Number and dispersion pattern (size, shape and dispersion) of soil types, capabilities, and moisture and chemical parameters.

- **Plant Community Level:**
  - The range in number and abundance of plant species common to natural ecosystems as compared to the number and abundance of plant species found in the similar reclaimed ecosystem established, noting any endangered or vulnerable species in the predisturbance and reclaimed landscape,
  - The diversity of vertical structures and productivities compared to natural systems,
  - The range of site indexes for each plant community type,
  - The abundance of indicator species and composition of indicator assemblages, and
  - The abundance of exotic or hybrid species.

- **Within Species (Genetic) Level:**

  For each species the following information should be documented or measured:

  - The source location and elevation of seed or revegetative material,
  - The numbers of seed sources and hence genetic diversity of plant material,
  - Genetic composition of seed sources,
  - Where applicable: variability in growth rates, nutrient cycling and successional trajectory,
  - The types and abundance of insects and disease, and
  - Variability in tree mortality rates and gap initiation.

Biodiversity monitoring methods are diverse and some potential methods are referenced in Schneider (1997, Appendix E).

7. ONGOING PROCESS REFINEMENT BASED ON MONITORING AND RESEARCH

These guidelines will be updated approximately every five years with new information derived from monitoring programs (described in Section 6.0) and research programs (described in Section 3.3).

8. GLOSSARY OF TERMS

BIODIVERSITY: Biodiversity is the variety of living components of ecosystems. Biodiversity within plant communities is composed of the range of genetic, species, structural, and functional diversity. Structural diversity being the structure of plant communities both horizontally and vertically, while functional diversity encompasses the physiological differences between vegetation.

CAPABILITY See Land, Landscape and Soil Capability.

COMPOSITE/CONSOLIDATED TAILINGS: Composite (syncrude) and consolidated (suncor) tailings is formed by injecting mature fine tailings from the tailings ponds into the regular tailings sand stream, with a floculant such as gypsum. This mixture is sent to the tailings ponds to form a non-segregating soil mixture which will result in a trafficable surface in the reclaimed landscape.

ECOSITE: Ecological units that develop under similar environmental influences (climate, moisture, and nutrient regime). Ecosites are groups of one or more ecosite phases that occur within the same portion of the edatope (e.g., Lichen ecosite). Ecosite, in this classification system, is a functional unit defined by moisture and nutrient regime. It is not tied to specific landforms or plant communities as in other systems (lacate 1969), but is based on the combined interaction of biophysical factors that together dictate the availability of moisture and nutrients for plant growth. Thus, ecosites are different in their moisture regime and/or nutrient regime (Beckingham and Archibald, 1996).

ECOSITE PHASE: A subdivision of the ecosite based on the dominant tree species in the canopy. On some sites where a tree canopy is lacking, the tallest structural vegetation layer determines the ecosite phase (e.g., Shrubby and graminoid phases). Some variation in humus form or plant species abundance may be observed between ecosite phases (Beckingham and Archibald, 1996).

ECOSYSTEM: A system of living organisms interacting with each other and their environment, linked together by energy flows and material cycling.

EDATOPE: Moisture/nutrient grid that displays the potential ranges of relative moisture (very dry to wet) and nutrient (very poor to very rich) conditions and outlines relationships between each of the ecosites.

EQUIVALENT CAPABILITY:	The ability of the land to support various land uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land, but that the individual land uses will not necessarily be identical.
EXOTIC SPECIES:	In this document, exotic species refer to plant species that are not native to the province and which are not native within the natural region of interest.
GRAMINOID PHASE:	In the ecosite classification, graminoid phases are those ecosite phases dominated by grass or sedge species.
HABITAT SUITABILITY INDEX:	Habitat Suitability Index Models estimate the value of habitat for wildlife species by relating a species' need for food and cover to structural and spatial attributes of vegetation types within a defined area. The Habitat Suitability Index (HSI) refers to the quality or suitability for a species or species group, and ranges in value from 1.0 (optimal value) to 0.0 (no value).
HYDRIC:	A soil moisture regime used to describe sites where the water table is at or above the soil surface all year.
HYGRIC:	A soil moisture regime used to describe sites where water is removed slowly enough to keep the soil wet for most of the growing season.
LAND CAPABILITY:	Ability of land to support a given land use, based on an evaluation of the physical, chemical and biological characteristics of the land, including topography, drainage, hydrology, soils and vegetation.
LANDSCAPE CAPABILITY:	The evaluation of landscape factors as they affect general tree growth including: slopes, position, aspect, stoniness and erosion.
LICHENS:	A group of organisms consisting of fungi and algae growing together symbiotically.
MAP UNIT:	A mappable portion of the soil landscape with attributes varying within narrow limits that are determined by the intensity of survey and its objectives such as land use planning and management requirements.
MESIC:	A soil moisture regime used to describe sites where water is removed somewhat slowly in relation to supply and where soil may remain moist for significant but sometimes short periods of the growing season.

MONTANE: A climatic region in alberta defined in the natural regions and subregions of alberta. The montane subregion is characterized by forests of lodgepole pine, douglas fir, white spruce and aspen.

NATIVE SPECIES: Species native to the province and to the natural sub-region of interest.

OVERSTOREY SPECIES: An overstorey is the tallest vegetation layer within a plant community and most often consists of trees in the oil sands area. An overstorey species is a species that occurs within the overstorey vegetation layer.

PASSERINES: A group of perching birds belonging to the zoological order *passeriformes.*

PEAT-MINERAL MIX: A mixture of peat and mineral material resulting in a "mineral" soil. Peat-mineral mixes typically contain a ratio of peat:mineral ranging from about 1:1 to 1:4 (volume basis).

PLANT COMMUNITY TYPE: A subdivision of the ecosite phase and the lowest taxonomic unit in the classification system. While plant community types of the same ecosite phase share vegetational similarities, they differ in their understorey species composition and abundance. These differences may not be mappable from aerial photography but may be important to wildlife, recreation, and other resource sectors (Beckingham and Archibald 1996).

PRODUCTIVITY: Evaluation of tree growth by site index which is a measurement of tree growth expressed as height (m) at 50 years breast height and/or by mean annual increment expressed as volume m^3/ha.

RECLAIMED SOIL: Soil created by the selective placement of suitable topsoil and subsoil material on reshaped spoil, or parent geological material.

REFUGIA: A stand of undisturbed natural vegetation retained within a mine development area that serves as a source of native species for revegetation.

RIPARIAN: Areas or species associated with river or creek systems or other wetlands.

SOIL: Unconsolidated, mineral or organic material at the surface of the earth that serves as a medium for plant growth.

SOIL CAPABILITY: The nature and degree of limitations imposed by the physical, chemical and biological characteristics of a soil for forest productivity.

SOIL SERIES: A soil series is a conceptual class that has defined limits of relatively detailed soil properties including horizon depth and expression, color, texture, structure, consistence, stoniness, salinity, ph and soil drainage. In soil mapping, the names of soil series are often used to name the map units.

SOIL TYPE: In ecosite classification soil types are functional taxonomic units used to stratify soils based on soil moisture regime, effective soil texture, organic matter, thickness, and soil depth. The concept of the soil type is more general than that of a soil series in this context.

SUBHYDRIC: A soil moisture regime used to describe sites where the water table is at or near the surface for most of the year.

SUBHYGRIC: A soil moisture regime used to describe sites where water is removed slowly enough to keep the soil wet for a significant part of the growing season.

SUBMESIC: A soil moisture regime used to describe sites where water is removed readily in relation to supply and where water is available for moderately short periods following precipitation.

SUBXERIC: A soil moisture regime used to describe sites where water is removed rapidly in relation to supply and where soil is moist for only short periods following precipitation.

TAXONOMIC UNIT: A classified unit within a hierarchical classification system. In this case the hierarchical classification system is the ecological classification system (Beckingham and Archibald 1996).

UNDERSTOREY SPECIES: A vegetation species found in one of the lower vegetation layers within a plant community; lower layers are commonly shrub, grass or moss layers.

VEGETATION: The species which comprise a plant community including trees, shrubs, forbs, graminoids, mosses, and lichens.

VERY XERIC: A soil moisture regime used to describe sites where water is removed extremely rapidly in relation to supply and soil is moist for a negligible period following precipitation.

XERIC: A soil moisture regime used to describe sites where water is removed very rapidly in relation to supply and soil is moist only for brief periods following precipitation.

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APPENDIX A

EXISTING ECOSITES IN THE OIL SANDS REGION

EXISTING ECOSITES IN THE OIL SANDS REGION

Prepared by Judith Smith and Kimberly Ottenbreit, BOVAR Environmental

A1.0 OVERVIEW

This overview of local ecosystems in the oil sands region describes the most common terrestrial ecosystems, their dominant plant species composition, successional status, and the ecological factors that explain their position in the landscape. The description is focused on terrestrial ecosystems, although the aquatic ecosystems are outlined briefly.

An Ecosystem is an interacting, dynamic system of living organisms (plants, animals, fungi, bacteria) and the physical environment (soil, air, water, bedrock). Ecosystems are determined by climate, landform, topography, soils, animals and vegetation.

An Ecological Classification System (ECS) is an attempt to organize these complex systems and functions into understandable and workable units. The ecosystems described for the oil sands region are based on the Ecological Classification System prepared by Beckingham and Archibald (1996) for the Boreal Forest and Canadian Shield Natural Areas of Alberta.

- The ECS consists of an integrated hierarchical ecological system with three levels: ecosite, ecosite phase and plant community type, and a separate soil classification.

- The ECS is nested within Alberta geographically based on the Natural Region and Subregion Classification System prepared by Alberta Environmental Protection (1994).

A1.1 ECOLOGICAL UNITS

Table A.1 illustrates the Ecological Units in the oil sands region, using the two classification systems outlined. The units are defined through an analysis of climate, vegetation, soils and sites i.e., topography, slope, aspect, etc. The highest Ecological Unit is the Natural Region and the lowest unit is the Plant Community Type.

Table A.1
Ecological Classification System for the Oil Sands Region

Classification Level	Ecological Unit Definition	Oil Sands Classification
Natural Region	–	Boreal Forest
Subregion	Similar climate, natural vegetation and to lesser extent soils	Central Mixedwood
Ecosite	Similar moisture and nutrient regimes	12 units (e.g., lichen)
Ecosite Phase	Similar dominant species in the canopy (i.e. trees, shrubs)	25 units (e.g., jack pine lichen)
Plant Community Type	Similar understory species composition and abundance	73 units (e.g., bearberry, blueberry, or alder)

Source: Beckingham and Archibald (1996).

The oil sands area is located within the Boreal Forest Natural Region and the Central Mixedwood Subregion. The following is a description of the some of the characteristics of the subregion:

- Climate is sub-arid to sub-humid, and cool continental, which is characterized by long, cold winters and short, warm summers.
- Topography is largely subdued although hill complexes and uplands are present i.e., Firebag and Thickwood Hills, and Birch Mountains.
- Dominant tree species is trembling aspen, with other common species being black spruce, white spruce, jack pine and balsam poplar.
- Succession is typically to white spruce and balsam fir. However, frequent fires often occur before this climax plant community is reached.
- Dominant soils are Organic, Gray Luvisols, Brunisols and Gleysols.

Ecosites are subunits of the Subregion, defined by their positions on an edatophic grid based on nutrient and moisture regime.

Ecosites are subdivided into Ecosite Phases based on plant canopy cover.

Ecosites phases are subdivided into Plant Community Types based on the composition and abundance of the understory vegetation.

A1.2 CHARACTERISTICS OF ECOSITES, ECOSITE PHASES AND PLANT COMMUNITY TYPES IN THE OIL SANDS AREA

This section provides a brief review of the 12 ecosites described by Beckingham and Archibald (1996) for the boreal mixedwood area. Plant communities may vary based on topography and soil type. For example, dry, sandy sites may have jack pine, whereas wetlands may be treed with black spruce and/or larch.

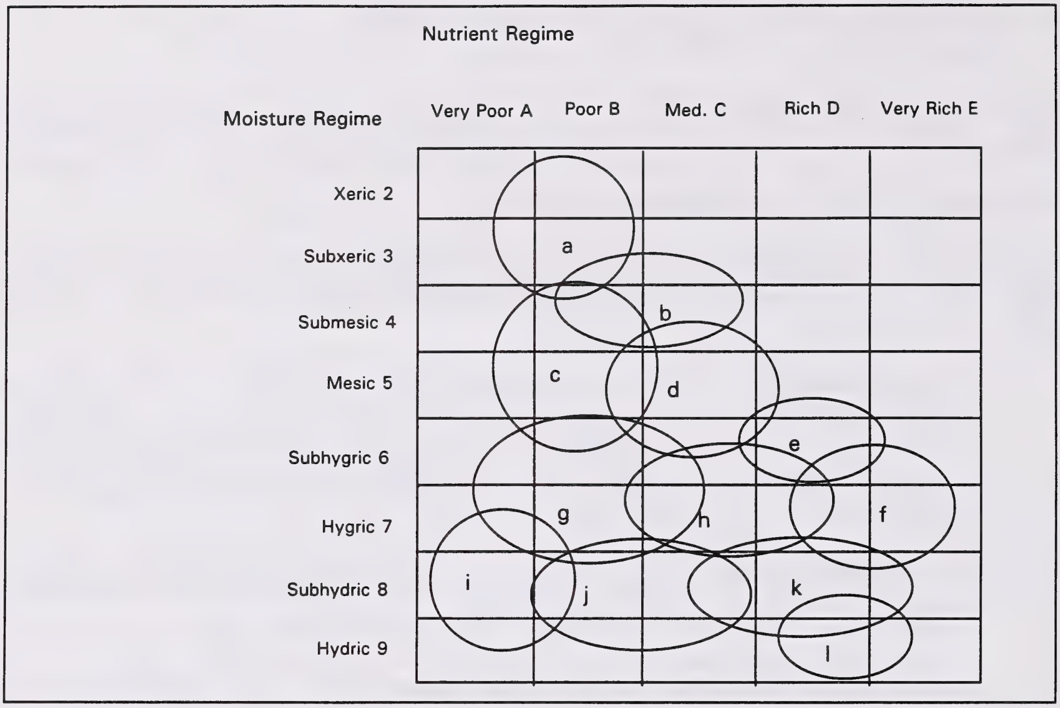
The 12 ecosites are spatially arranged on an edatopic grid based on nutrient and moisture regime (Figure A.1). These are then subdivided into ecosite phases and plant communities as listed in Figure A.2.

- **a or lichen ecosite**. The nutrient regime is poor and the moisture regime is xeric to subxeric. There is one ecosite phase, namely jack pine, and three plant communities: bearberry, blueberry, or green alder. These sites occur on dry, coarse-textured, well-drained soils. Succession to black spruce is generally precluded by fire. Drought limitations are to be considered on this ecosite.

- **b or blueberry ecosite**. The nutrient regime is poor to medium and the moisture regime is subxeric to submesic. There are four ecosite phases associated with this ecosite. These are: pine/aspen, aspen (white birch), aspen/white spruce, and white spruce/pine. The plant communities are separated based on the cover value of blueberry, green alder and Labrador tea. Hairy wild rye can be found on these sites as well. As in the lichen ecosite, the soils are relatively dry, rapidly drained and coarse-textured. Succession may proceed to a white spruce dominated phase. Drought limitations are a factor on these sites.

- **c or Labrador tea (mesic) ecosite**. The nutrient regime is poor and the moisture regime is mesic. There is one ecosite phase which is jack pine/black spruce. Ground cover is dominated by Labrador tea, green alder and/or feathermoss. Successionally, this ecosite trends towards black spruce but this is rare owing to fire.

- **d or low-bush cranberry ecosite.** This ecosite is located centrally in the edatopic grid. It is medium in terms of nutrient regime and mesic in moisture. There are three ecosite phases: aspen, aspen/white spruce and white spruce. Several understory species determine plant community type. These include low-bush cranberry, buffaloberry, saskatoon, rose, alder, hazelnut and feathermoss. Deciduous species will succeed to white spruce. As coniferous canopy increases, understory vegetation will decline resulting in a higher moss cover. Vegetation competition is high in this ecosite.



Ecosites:

a = **lichen**
subxeric/poor

b = **blueberry**
submesic/medium

c = **Labrador tea-mesic**
mesic/poor

d = **low-bush cranberry**
mesic/medium

e = **dogwood**
subhygric/rich

f = **horsetail**
hygric/rich

g = **Labrador tea-subhygric**
subhygric/poor

h = **Labrador tea/horsetail**
hygric/medium

i = **bog**
subhygric/very poor

j = **poor fen**
subhydric/medium

k = **rich fen**
subhydric/rich

l = **marsh**
hydric/rich

Figure A.1 Edatope (moisture/nutrient grid) Showing The Location Of Ecosites For The Boreal Mixedwood

Ecosite	Ecosite Phase	Plant Community Type
a lichen (subxeric/poor)	a1 lichen Pj	a1.1 Pj/bearberry/lichen
		a1.2 Pj/blueberry/lichen
		a1.3 Pj/green alder/lichen
b blueberry (submesic/medium)	b1 blueberry Pj-Aw	b1.1 Pj-Aw/blueberry–bearberry
		b1.2 Pj-Aw/blueberry–green alder
		b1.3 Pj-Aw/blueberry–Labrador tea
	b2 blueberry Aw(Bw)	b2.1 Aw(Bw)/blueberry–bearberry
		b2.2 Aw(Bw)/blueberry–green alder
		b2.3 Aw(Bw)/blueberry–Labrador tea
	b3 blueberry Aw-Sw	b3.1 Aw-Sw/blueberry–bearberry
		b3.2 Aw-Sw/blueberry–green alder
		b3.3 Aw-Sw/blueberry–Labrador tea
	b4 blueberry Sw-Pj	b4.1 Sw-Pj/blueberry–bearberry
		b4.2 Sw-Pj/blueberry–green alder
c Labrador tea–mesic (mesic/poor)	c1 Labrador tea–mesic Pj-Sb	c1.1 Pj-Sb/Labrador tea/feather moss
		c1.2 Pj-Sb/green alder/feather moss
		c1.3 Pj-Sb/feather moss
d low-bush cranberry (mesic/medium)	d1 low-bush cranberry Aw	d1.1 Aw/Canada buffalo-berry
		d1.2 Aw/saskatoon–pin cherry
		d1.3 Aw/beaked hazelnut
		d1.4 Aw/green alder
		d1.5 Aw/low-bush cranberry
		d1.6 Aw/rose
		d1.7 Aw/beaked willow
		d1.8 Aw/forb
		d1.9 Aw/balsam fir
	d2 low-bush cranberry Aw-Sw	d2.1 Aw-Sw/Canada buffalo-berry
		d2.2 Aw-Sw/beaked hazelnut
		d2.3 Aw-Sw/green alder
		d2.4 Aw-Sw/low-bush cranberry
		d2.5 Aw-Sw/rose
		d2.6 Aw-Sw/beaked willow
		d2.7 Aw-Sw/forb
		d2.8 Aw-Sw/balsam fir/feather moss
		d2.9 Aw-Sw/feather moss
	d3 low-bush cranberry Sw	d3.1 Sw/Canada buffalo-berry
		d3.2 Sw/green alder
		d3.3 Sw/low-bush cranberry
		d3.4 Sw/balsam fir/feather moss
		d3.5 Sw/feather moss
e dogwood (subhygric/rich)	e1 dogwood Pb-Aw	e1.1 Pb-Aw/dogwood/fern
		e1.2 Pb-Aw/bracted honeysuckle/fern
		e1.3 Pb-Aw/river alder/fern
	e2 dogwood Pb-Sw	e2.1 Pb-Sw/dogwood/fern
		e2.2 Pb-Sw/bracted honeysuckle/fern
		e2.3 Pb-Sw/river alder–green alder/fern
		e2.4 Pb-Sw/balsam fir/fern
		e2.5 Pb-Sw/fern/feather moss
	e3 dogwood Sw	e3.1 Sw/dogwood/fern
		e3.2 Sw/green alder–river alder/fern
		e3.3 Sw/balsam fir/fern
		e3.4 Sw/fern/feather moss
f horsetail (hygric/rich)	f1 horsetail Pb-Aw	f1.1 Pb-Aw/horsetail
	f2 horsetail Pb-Sw	f2.1 Pb-Sw/horsetail
	f3 horsetail Sw	f3.1 Sw/horsetail
		f3.2 Sw/feather moss
g Labrador tea–subhygric (subhygric/poor)	g1 Labrador tea–subhygric Sb-Pj	g1.1 Sb-Pj/Labrador tea/feather moss
		g1.2 Sb-Pj/feather moss
h Labrador tea/horsetail (hygric/medium)	h1 Labrador tea/horsetail Sw-Sb	h1.1 Sw-Sb/Labrador tea/horsetail
		h1.2 Sw-Sb/Labrador tea/feather moss
i bog (subhydric/very poor)	i1 treed bog	i1.1 Sb/Labrador tea/cloudberry/peat moss
	i2 shrubby bog	i2.1 black spruce–Labrador tea/cloudberry/peat moss
j poor fen (subhydric/medium)	j1 treed poor fen	j1.1 Sb-Lt/dwarf birch/sedge/peat moss
	j2 shrubby poor fen	j2.1 black spruce–tamarack–dwarf birch /sedge/peat moss
k rich fen (subhydric/rich)	k1 treed rich fen	k1.1 Lt/dwarf birch/sedge/golden moss
	k2 shrubby rich fen	k2.1 dwarf birch/sedge/golden moss
		k2.2 willow/sedge/brown moss
		k2.3 willow/marsh reed grass
	k3 graminoid rich fen	k3.1 sedge fen
		k3.2 marsh reed grass fen
l marsh (hydric/rich)	l1 marsh	l1.1 cattail marsh
		l1.2 reed grass marsh
		l1.3 bulrush marsh

Figure A.2 Ecological Units of the Boreal Mixedwood

- **e or dogwood ecosite**. The nutrient regime is rich and the moisture regime is subhygric. There are three ecosite phases: balsam poplar/aspen, balsam poplar (aspen)/white spruce and white spruce. Indicator species of this ecosite include dogwood, river alder, and bracted honeysuckle. Another key indicator of this ecosite is the presence of ferns such as oak fern, lady fern and shield fern. These plant communities commonly occur along riverine or seepage areas which receive nutrients. They are high in species diversity and plant competition. This tends to be the most productive ecosite.

- **f or horsetail ecosite**. The nutrient regime is rich to very rich and the moisture regime is hygric. There are the same three ecosite phases as with the dogwood ecosite. Ground cover is dominated by horsetails. This ecosite is successional to white spruce. Sensitive to disturbance as water table may rise if trees are removed. Soil temperature and plant competition are high.

- **g or Labrador tea (subhygric) ecosite.** The nutrient regime is poor and the moisture regime is subhygric to hygric. There is one ecosite phase which is black spruce/jack pine. The understory vegetation is Labrador tea, feathermoss. Successionally mature stands maintain a small component of jack pine, but are black spruce dominated. Soil temperature and excess moisture may be limitations to productivity of this ecosite.

- **h or Labrador tea-horsetail ecosite**. The nutrient regime is medium and the moisture regime is hygric. There is one ecosite phase which is white spruce/black spruce. Main understory species are Labrador tea, horsetail, and feathermoss. Excess moisture and soil temperature limitations characterize this ecosite.

- **i or bog ecosite**. This ecosite is poor in nutrient regime and subhydric in moisture. Black spruce, Labrador tea, cloudberry and peatmoss characterize the ecosite. The water table maintains an edaphic climax community in the (i), (j) and (k) ecosites. Soil temperature limitations and excess moisture are considerations on these ecosites as well.

- **j or poor fen ecosite**. The nutrient regime is poor to medium and the moisture regime is subhydric. This ecosite is characterized by the presence of black spruce/larch, Labrador tea/dwarf birch, cloudberry/sedge and peatmoss/golden moss.

- **k or rich fen ecosite**. The nutrient regime is rich and the moisture regime is subhydric. This ecosite is characterized by the following species: larch, dwarf birch, sedge, golden moss and tufted moss. Other indicator species of this ecosite may include bog bean and marsh marigold.

Nonforested communities also occur in the area. In addition to this, there are shrubby bogs (i) and fens (j, k) and graminoid fens (k). These simply lack the overstory canopy of trees and/or shrubs.

- **l or marsh ecosite.** The nutrient regime is rich and the moisture regime is hydric. These are graminoid dominated plant communities which include: bulrushes, cattails and reed grasses. Excess moisture is a limiting factor in this ecosite.

There is always considerable natural variability in the landscape with ecotones being common. Thus, not all sites can be easily distinguished and classified. This is evident, for example, in the positions of the ecosites on the grid, as they always intergrade with other, adjacent sites. In addition, species will often be found growing in areas for which they are not best adapted, or in suitable microsites.

Because of the complexity of plant communities they are very difficult to imitate or replace. However, an understanding of the natural plant communities and the many factors which influence their structure, provides a framework to assist us in re-creating these communities.

A1.3 MOISTURE REGIME CLASSES

Very Xeric	Water removed extremely rapidly in relation to supply; soil is moist for a negligible time after precipitation.
Xeric	Water removed very rapidly in relation to supply; soil is moist for brief periods following precipitation.
Subxeric	Water removed rapidly in relation to supply; soil is moist for short periods following precipitation.
Submesic	Water removed readily in relation to supply; water available for moderately short periods following precipitation.
Mesic	Water removed somewhat slowly in relation to supply; soil may remain moist for significant but sometimes short periods of the year, available soil water reflects climatic input.
Subhygric	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possible mottling below 20 cm.
Hygric	Water removed slowly enough to keep the soil wet for most of the growing season; permanent seepage and mottling present; possibly weak gleying.
Sybhydric	Water removed slowly enough to keep the water table at or near the surface for most of the year; organic and gleyed mineral soils; permanent seepage less than 30 cm below the surface.
Hydric	Water removed so slowly that the water table is at or above the soil surface all year; organic and gleyed mineral soils.

A2.0 LITERATURE CITED

Alberta Environmental Protection. 1994. Natural Regions of Alberta. Edmonton, Alberta.

Beckingham, J.D. and J.H. Archibald. 1996. Field Guide to Ecosites of Northern Alberta. Natural Resources Canada, Canadian Forest Service, Northwest Region, North. For. Cent. Spec. Rep. 5. Edmonton, Alberta.

APPENDIX B

CAPABILITIES AND DIVERSITY OF EXISTING SOILS WITHIN SOME OIL SANDS LEASES

CAPABILITIES AND DIVERSITY OF EXISTING SOILS WITHIN SOME OIL SANDS LEASES

Prepared by Leonard Leskiw, Can-Ag Enterprises Ltd.

B1.0 BASELINE SOILS AND VEGETATION

B1.1 STEEPBANK MINE

A comparison of soils and site index values for the Steepbank Mine Area was made by overlying the Alberta Vegetation Inventory polygons on the detailed soil survey. The soils ratings are based on the modal profile representing the soil series. Site indices are estimated for each polygon based on measurements from a number of sample plots located throughout the study area (Table B.1). These results are therefore approximate. In future mapping, it is recommended that soils descriptions and site index measurements be made at the same points. If suitable plots are selected, in terms of density, age and health, there is much more likelihood of observing a good correlation between soil capability and tree productivity. If random plots are located to characterize stands, as for inventory purposes, the soil capability and tree productivity relationships are weaker. It is important that the same approach be used for comparing baseline and reclaimed productivity levels.

Table B.1
Soil and Site Index Information for the Steepbank Mine Area

Soil Series	Classification	Parent Material	Texture		Moisture Regime	LFH Or Peat Thickness (cm)	Soil Capability	Mean Site Index at 50 Years	Range In Site Index at 50 Years
			Surface	Sub-surface					
Algar	Gleysol	M[a], F	Peat	SCL[b], CL	hygric, subhydric	25	4	12	7-17
Firebag (Mildred)	Brunisol	F, M	LS, SL	SL, S	xeric, subxeric	7	3	13	7-17
Kinosis	Luvisol	M, F	SL, LS	SCL, CL	mesic, subhygric	11	2	15	13-17
McLelland	Mesisol (fen)	O	Peat	peat	subhydric, hydric	>50	5	4	4
McMurray	Regosol	F, F/M	SiL, L	SL, S	mesic	20	2, 1	15	10-21
Gleyed McMurray	Gleyed Regosol	F, F/M	SiL, L	SL, S	hygric	6	5, 4	11	5-18
Muskeg	Mesisol (bog)	O	Peat	peat	hygric subydric	>50	5	10	3-17
Rough Broken 2	Brunisol Luvisol	F/tar sand	SL	tar sand	subxeric-subhygric	6	2, 3	13	6-19
Rough Broken 3	Regosol Luvisol	M, M/r	SL	SCL	subxeric-subhygric	17	3, 4	13	3-19

[a] F = fluvial; M = morainal; O = organic; r = residual
[b] C = clay; L = loam; S = sand; Si = silt

B1.2 AURORA MINE

Soil capability ratings were assigned to representative profiles and these were compared with a number of site index values for selected vegetation plots for the Aurora Mine Area. The moisture regime and soil map unit were indicated for each vegetation plot, but a soil profile description was not available for each plot. Therefore, vegetation plots were selected only if the moisture regime matched that of the representative profile. Table B.2 shows a summary of the soil series, capability and site index relationship. Table B.3 shows individual plot data, thereby providing a breakdown of site index by species for each ecosite and series combination. Note that the vegetation plots were established to characterize the existing vegetation, so the site indices reflect actual growth rather than "potential" growth. In future mapping, it is necessary to have soils and site index rated at the same points, preferably at carefully selected plots (appropriate age, density, health).

Table B.2
Ecosites, Soils, Capability and Site Indices for Selected Sites at the Proposed Aurora Mine Area

Ecosite	Soil Series	Classifi-Cation	Parent Material[a]	Surface/ Subsurface Texture[b]	Moisture Regime	Soil Capability	Site Index at 50 Years		Number Of Plots
							Mean	Range	
lichen	Fort	Luvisol	F	SL/SCL	subxeric	3	13.0	10-14	7
	Mildred	Brunisol	F	S/LS	mesic	4	15.0	14-16	2
blueberry	Dalkin	Brunisol	FE/F	LS/S	submesic	4	11.4	8-15	5
	Fort	Luvisol	F	SL/SL	subxeric	3	8.8	7-12	4
low-bush cranberry	Algar	Gleysol	L	pt/L,SL,C	hygric	4	11.0	10-12	2
	Dover	Luvisol	L/M	L/C	mesic	3	20.8	16-26	4
	Fort	Luvisol	F	SL/SCL	submesic	2	21.0	20-22	2
	Mildred	Brunisol	F	S/LS	mesic	3	20.3	15-24	4
	Steepbank	Gleysol	F/M	pt/CL,SCL	hygric (aerated)	2	15.7	14-19	3
horsetail	Bitumount	Gleysol	F	pt/S,LS,SL	subhydric	5	9.4	8-13	4
Labrador tea	Livock	Luvisol	F/M	SiL/SiCL,CL	submesic	2	11.0	9-13	2
bog	Algar	Gleysol	L	pt/L,SL,C	hygric	4	11.0	11	1
	Bitumount	Gleysol	F	pt/S,LS,SL	subhydric	5	6.0	5-8	3
	Hartley	Mesisol	O/M	pt/pt	subhydric	5	8.2	7-11	5
	McLelland	Mesisol	O	pt/pt	subhydric	5	12.5	7-23	4
	Muskeg	Mesisol	O	pt/pt	hydric	5	11.0	8-14	2
	Steepbank	Gleysol	F/M	pt/CL;SCL	hygric (reduced)	4	8.4	5-12	5
poor fen	Bitumount	Gleysol	F	pt/S,LS,SL	subhydric	5	10.7	6-14	3
	Hartley	Mesisol	O/M	pt/pt	subhydric	5	14.5	8-22	6
rich fen	Hartley	Mesisol	O/M	pt/pt	subhydric	5	10.5	8-13	2
	Mariana	Mesisol	O/M	pt/pt	hydric	5	14.0	12-16	2
	Muskeg	Mesisol	O	pt/pt	hydric	5	11.0	10-12	2

[a] F = fluvial; M = morainal; O = organic; pt = peat
[b] C = clay; L = loam; S = sand; Si = silt
Note: One soil profile rating for each soil type; Number of Plots refers to the number of vegetation plots on that soil for that ecosite.
Source: BOVAR Environmental (1996) updated to match Leskiw 1998 and Table B.3

Table B.3
Selected Site Data Relating Tree Growth and Soils at the Proposed Aurora Mine Area

Ecosite	Series	Species	% cover	DBH (cm)	Height (m)	Age (br.hgt)	Site Index	Soil Drainage	Soil Perviousness	Moisture Regime
lichen	Fort	Pj	25	17.5	13.7	46	14	well	moderate	subxeric
		Pj	60	17.5	11.6	65	10	rapid	rapid	xeric
		Pj (u)	5	10	10.2	32	14	rapid	rapid	xeric
		Aw (u)	5	9.5	7.8	29	13	moderate	moderate	subxeric
		Pj	70	18	14.8	55	14	moderate	moderate	subxeric
		Pj	15	15.1	12.8	41	15	rapid	rapid	xeric
		Pj	30	11.7	13.2	42	15	well	rapid	subxeric
	Mildred	Pj	35	22.7	17.5	58	16	well	moderate	mesic
		Pj	40	18.7	14.2	50	14	moderate	moderate	submesic
blueberry	Dalkin	Aw	7	18.5	11.9	80	8	well	moderate	submesic
		Aw (u)	5	9.5	10.5	32	15	well	moderate	submesic
		Pj	30	22	11.3	56	11	well	moderate	submesic
		Sb (u)	5	15.5	9.4	39	11	well	moderate	submesic
		Sw	20	18	11.9	48	12	well	moderate	submesic
	Fort	Aw (u)	10	9.5	9.3	52	9	well	moderate	mesic
		Bw (u)	5	6	6.8	48	7	well	moderate	mesic
		Pj	10	28	11.4	46	12	well	moderate	mesic
		Sw	20	19	12.1	81	7	well	moderate	mesic
lowbush	Fort	Aw	60	20.7	19.8	52	20	well	moderate	submesic
cranberry		Aw	70	15.8	23	57	22	imperfect	mod-slow	hygric
	Mildred	Aw	60	18.2	21	56	20	well	moderate	submesic
		Bw	1	12.8	12.5	39	15	well	moderate	submesic
		Aw	60	13.3	18.9	32	24	moderate	moderate	mesic
		Aw	40	14.7	19.2	40	22	well	moderate	mesic
	Steepbank	Aw	86	19	21.6	104	14	well	moderate	mesic
		Aw (u)	40	7.5	10.8	23	19	poor	slow	hygric
		Bw (u)	5	9	11	38	14	poor	slow	hygric
	Algar	Aw	35	9	9.5	52	10	imperfect	moderate	hygric
		Sb	25	12.3	9.5	35	12	imperfect	moderate	hygric
	Dover	Aw	40	22.6	20.1	70	16	moderate	moderate	subhygric
		Sw	20	31.9	26.2	72	21	moderate	moderate	subhygric
		Aw	30	12	11.6	28	17	well	moderate	mesic
		Sw	20	15.7	13.7	39	16	well	moderate	mesic
horsetail	Bitumount	Bw	60	13	12.6	86	8	imperfect	slow	hygric
		Lt	5	12.5	9.8	91	13	imperfect	slow	hygric
		Sb	5	15.5	9.3	75	7	imperfect	slow	hygric
		Sw	10	11.5	11.4	54	10	imperfect	slow	hygric
Labrador tea	Livock	Pj	5	15.2	11.9	44	13	well	rapid	submesic
		Sb	10	11.2	7.9	41	9	well	rapid	submesic
bog	Algar	Sb	10	15	13.1	64	11	very poor	slow	subhydric
	Bitumount	Sb	15	10	6.5	71	5	poor	slow	subhydric
		Pb	5	10.2	8	51	5	imperfect	slow	subhygric
		Sb	50	10	7.9	52	8	imperfect	moderate	subhygric
	Hartley	Sb	5	7	6.3	42	8	poor	slow	subhydric

Table B.3 (cont'd)

Ecosite	Series	Species	% cover	DBH (cm)	Height (m)	Age (br.hgt)	Site Index	Soil Drainage	Soil Perviousness	Moisture Regime
		Sb	2	6.3	6.5	23	11	poor	slow	subhydric
		Sb	10	17	13	128	7	poor	slow	hygric
		Sb	8	7.8	6.6	40	8	poor	slow	hygric
		Sb	25	11.5	7.2	50	7	imperfect	moderate	subhygric
	McLelland	Sb	10	8.1	18.3	35	23	poor	slow	subhydric
		Sb	25	10.8	9.5	42	11	poor	slow	hygric
		Sb	10	11	6.3	47	7	very poor	slow	subhydric
		Sb	25	13	9.6	56	9	poor	slow	subhygric
	Muskeg	Sb	40	19	15.5	60	14	imperfect	slow	hygric
		Lt	2	7.5	5.1	25	8	very poor	slow	subhydric
	Steepbank	Sb	25	77	9	41	11	verypoor	slow	subhygric
		Sb	20	19.4	12.3	54	12	poor	slow	subhydric
		Sb	2	8	5.4	56	5	imperfect	slow	hygric
		Sb	10	18	16.7	137	9	poor	slow	hygric
		Sb (u)	25	12.5	9.7	119	5	poor	slow	hygric
poor fen	Bitumount	Lt	5	11	8.3	41	14	poor	slow	subhydrc
		Lt	5	11	7.9	74	12	poor	slow	subhydric
		Sb (u)	10	9	5.4	45	6	poor	slow	subhydric
	Hartley	Lt	5	13	13.7	39	22	imperfect	slow	hygric
		Sb	5	9	7	44	8	imperfect	slow	hygric
		Lt	20	18.4	12.3	40	20	poor	slow	hygric
		Sb (u)	8	9.5	6.4	32	9	poor	slow	hygric
		Lt	10	22.5	12	62	17	imperfect	slow	subhydric
		Sb	5	18.9	11.5	51	11	imperfect	slow	subhydric
rich fen	Hartley	Lt	7	12	6	179	8	very poor	slow	hydric
		Lt	5	17	7.5	42	13	poor	slow	hydric
	Mariana	Lt	15	12	10.7	56	16	poor	slow	hydric
		Lt	10	17.5	8.3	82	12	very poor	slow	hydric
	Muskeg	Lt	20	13.5	5.8	55	10	very poor	slow	hydric
		Sb	5	8.5	5.4	31	12	very poor	slow	subhydric

Source: Bovar Environmental 1996.

B1.3 SHELL LEASE 13

A detailed soil survey of the Shell Lease 13 project area was conducted in August, 1997. A summary of the soil and site index information is presented in Table B.4. Figure B.1 shows the relationship of soil capability and site index at 50 years based primarily on white spruce and some aspen. Trees were measured and aged at several soil inspection sites representing a cross-section of soil conditions.

B1.4 MILLENNIUM MINE, SUNCOR

A detailed soil survey of the Millennium project area was conducted in September, 1997. A summary of the soil and site index information is presented in Table B.5. Figure B.2 shows the relationship between soil capability and site index at 50 years. Species examined included mainly white spruce, black spruce and some jack pine. Trees were measured and aged at soil inspection sites.

B1.5 PERMANENT SAMPLE PLOT STUDY IN CENTRAL ALBERTA

A study of soil capability as related to site index at permanent sample plots was conducted in the agricultural fringe area in Central Alberta and the Peace River region (Leskiw *et al.* 1997). In this study, individual soil ratings and site index values were determined for the same points on mostly "good" plots. An adjustment was made for open jack pine stands (multiply site index by 0.60) to lower the site index values to be more representative of mean annual increment in open jack pine stands. These measurements reflect potential capability under natural growing conditions. Table B.6 provides a summary of soil and site index information, while Figure B.3 displays the resultant correlation.

B2.0 SITE INDICES

Actual site indices for ecosite phases that occur in the Syncrude Aurora Mine and the Suncor Millennium Mine are presented in Table B.7.

B3.0 LANDSCAPE AND SOIL DIVERSITY

The natural and reclaimed landscapes and soils each have a different range of conditions and diversity (Tables B.8 and B.9).

Overall, there is an opportunity to establish a similar or equivalent range of diversity in landscapes and soils, after reclamation compared to original conditions, though the specific types of landscapes and soils will likely differ. This can be accomplished through careful planning and implementation. Subsequent monitoring is required to confirm that targeted conditions are attained.

Table B.4
Soils and Average Site Index by Tree Species for 60 Sites in the Shell Lease 13 Project Area

Capability Class	SUMMARY DESCRIPTION				AVERAGE SITE INDEX BY TREE SPECIES AT 50 YEARS				
	Subgroup	Moisture Regime	Surface/ Subsurface	LFH or Peat depth (cm); median (range)	Aspen Aw (n)	White Spruce Sw (n)	Jack Pine Pj (n)	Black Spruce Sb (n)	Overall Site Index (n)
1	Gleyed Luvisol	Subhygric	SL / SL	15 (4-20)	- (0)	22 (3)	- (0)	- (0)	22 (3)
2	Brunisol Gleysol	Mesic Hygric (aerated)	SL, LS, SiL, / L, SL, LS, residual	13 (4-35)	22 (2)	19 (10)	10 (2)	18 (1)	18 (15)
3	Brunisol Luvisol	Submesic Mesic	LS, / LS, S, CL	4 (1-10)	18 (10)	18 (6)	10 (6)	- (0)	16 (22)
4	Brunisol Gleysol	Submesic Hygric (reduced)	S, LS, / S, LS, CL	7 (2-17)	- (0)	13 (4)	10 (9)	11 (4)	11 (17)
5	Mesisol	Subhydric	pt / pt	72 (11-160)	- (0)	- (0)	- (0)	11 (3)	11 (3)

[1] C = clay; L = loam; S = sand; Si = silt; pt = peat

Note: n = number of sites.

Table B.5
Soils and Average Site Index by Tree Species for 57 Sites in the Suncor Millenium Project Area

Capability Class	SUMMARY DESCRIPTION				AVERAGE SITE INDEX BY TREE SPECIES AT 50 YEARS				
	Subgroup	Moisture Regime	Surface/ Subsurface	LFH or Peat depth (cm); median (range)	Aspen Aw (n)	White Spruce Sw (n)	Jack Pine Pj (n)	Black Spruce Sb (n)	Overall Site Index (n)
1	Gleyed Luvisol	Subhygric	SL / CL	8 (6-20)	19 (3)	19 (4)	- (0)	- (0)	19 (7)
2	Luvisol Gleysol	Hygric Mesic (aerated)	SL, SiL / SCL, CL	10 (5-20)	17 (8)	17 (8)	- (0)	12 (1)	17 (17)
3	Luvisol	Mesic	LS, / SCL,	23 (5-40)	17 (1)	17 (1)	- (0)	- (0)	17 (2)
4	Gleysol	Hygric (reduced)	pt, SL, / SCL, CL	20 (10-50)	- (0)	- (0)	8 (1)	10 (14)	10 (15)
5	Mesisol	Subhydric	pt / pt	55 (0-120)	- (0)	8 (1)	10 (1)	9 (14)	9 (16)

[1] C = clay; L = loam; S = sand; Si = silt; pt = peat

Note: n = number of sites

Table B.6
Soils and Average Site Index by Tree Species for 80 Permanent Sample Plots in Central Alberta

Capability Class	SUMMARY DESCRIPTION				AVERAGE SITE INDEX BY TREE SPECIES AT 50 YEARS					
	Subgroup	Moisture Regime	Surface/ Subsurface	LFH or Peat depth (cm); median (range)	Aspen Aw (n)	White Spruce Sw (n)	Jack Pine Pj (n)	Lodgepole Pine Pl (n)	Black Spruce Sb (n)	Overall Site Index (n)
1	Gleyed Luvisol	Subhygric	SL, L, SiL / CL, SCL[a]	5(5-30)	20.8 (7)	19.8 (9)	24.8 (1)	24.0 (1)	24.3 (1)	20.9 (19)
2	Luvisol	Mesic	SiL, SL, L / CL, SCL, C	8(5-20)	18.8 (53)	18.9 (25)	15.2 (2)	16.1 (30)	13.8 (7)	17.6 (117)
3	Luvisol Brunisol	Submesic-mesic	SiL, LS, SL / SiL, SL, CL	5(0-5)	16.5 (2)	17.6 (4)	- (0)	12.5 (2)	- (0)	16.0 (8)
4	Brunisol Gleysol	Xeric-subxeric (sandy) or hygric (finer)	LS, S / S or SL,SCL/SL, SCL	5(0-30)	- (0) - (0)	- (0) 14.4 (4)	9.5 (19) - (0)	- (0) - (0)	- (0) 8.0 (2)	9.5 (19) 12.3 (6)
5	Mesisol	Subhydric	peat / peat	70(45-100)	- (0)	- (0)	- (0)	- (0)	5.7 (3)	5.7 (3)

[a] C = clay; L = loam; S = sand; Si = silt; pt = peat

Note: n= number of sites.

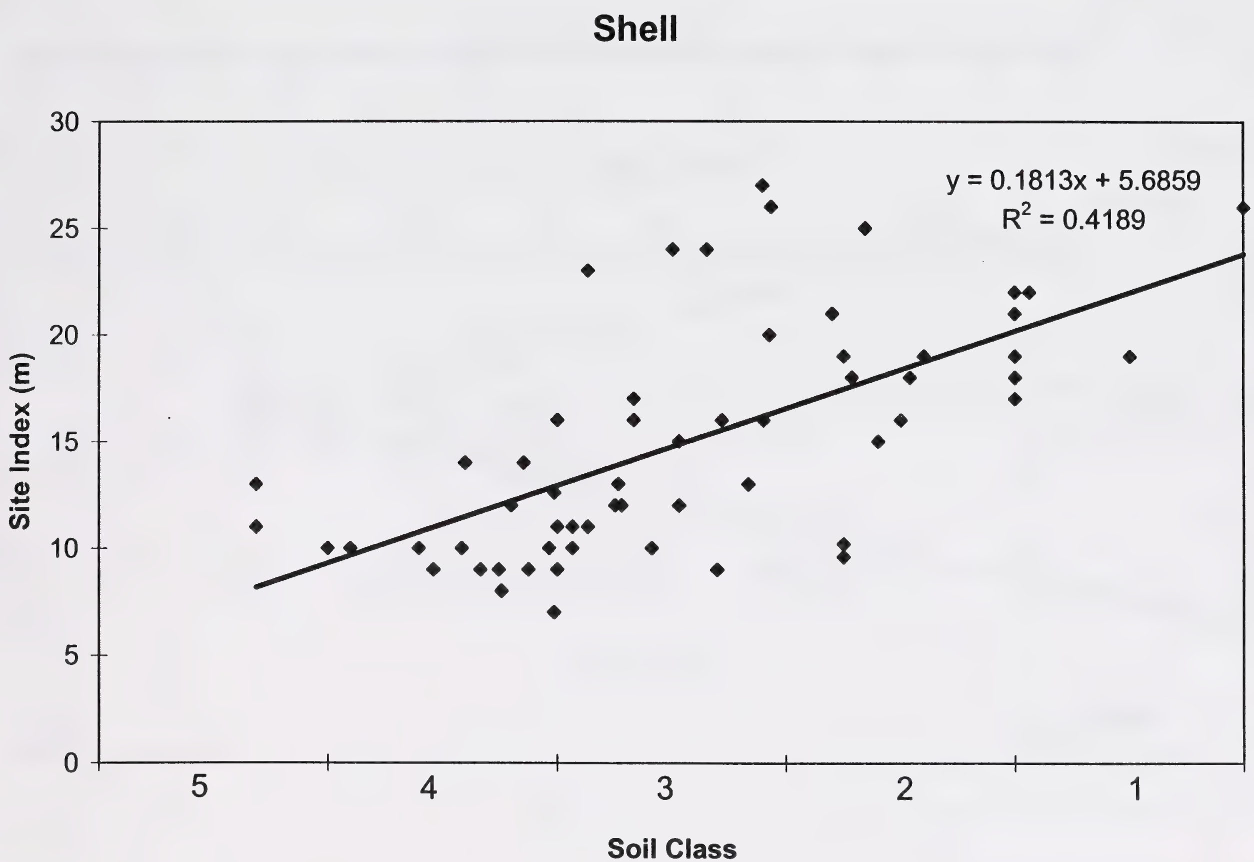


Figure B.1 Relationship Between Site Index and Soil Index for Sites in the Shell Lease 13 Project Area

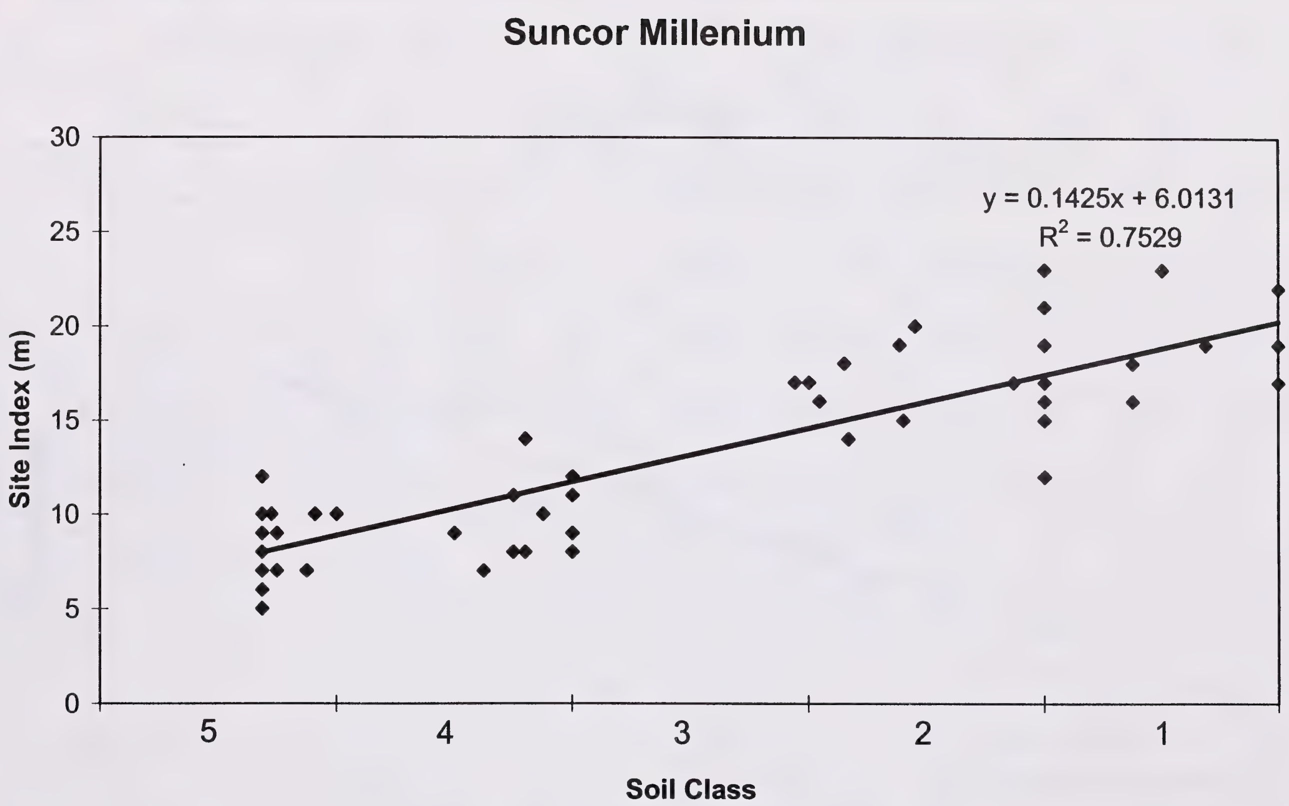


Figure B.2 Relationship Between Site Index and Soil Index for Sites in the Suncor Millenium Project Area

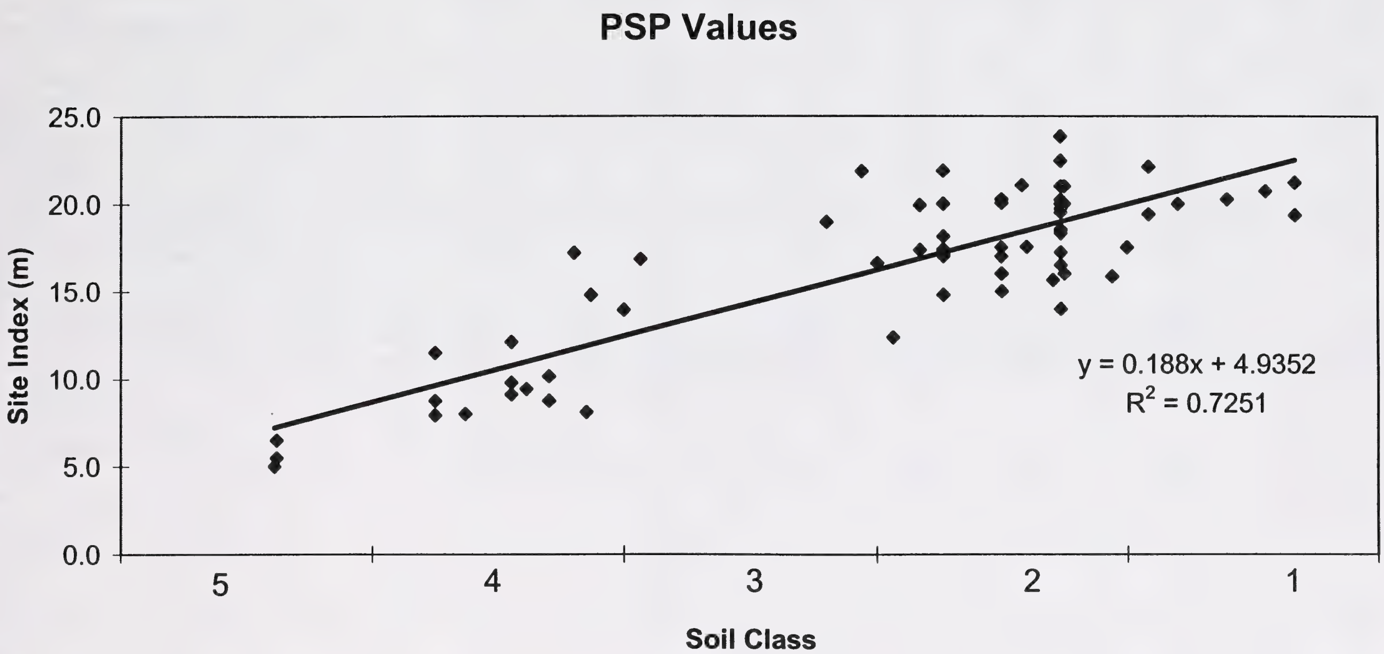


Figure B.3 Relationship Between Site Index and Soil Rating for 80 Permanent Sample Plots in Central Alberta

Table B.7
Site Index (at 50 years) of the Ecosite Phases from Beckingham and Archibald (1996) and Those Occurring in the Aurora Mine (the latter is based on ground-truthed plots)

Ecosites and Ecosite Phases		Beckingham and Archibald (1996)		Aurora Mine[a]				
		Number (n)	Site Index at 50 Years	Number (n)	SI (at 50 yrs)	Range in SI	Std. Dev.	Variance
a	jack pine/lichen	62	13.4	20	14	10-18	1.96	3.84
b	spen	56	15.8	6	13.2	11-16	3.06	9.37
	jack pine	29	14.3	8	14.8	12-19	3.24	10.50
	white spruce	28	17.5	6	14.2	7-20	4.36	18.97
b1	jack pine-aspen/blueberry							
	aspen	N/A	N/A	3	14	11-16	2.65	7.00
	jack pine	N/A	N/A	3	15	12-19	3.51	12.33
b3	aspen-white spruce/blueberry							
	aspen	N/A	N/A	1	14	--	0	0
	white spruce	N/A	N/A	1	15	--	0	0
b4	white spruce-jack pine/blueberry							
	white spruce	N/A	N/A	5	14	7-20	4.85	23.50
	jack pine	N/A	N/A	5	14	14-19	3.44	11.8
c	jack pine-black spruce/Labrador tea							
	jack pine	64	14.3	1	13	--	0	0
	black spruce	20	11.5	1	9	--	0	0
d	aspen	397	18.2	42	16.2	6-28	4.31	18.58
	white spruce	502	16.8	24	16.3	9-26	4.14	17.17
d1	aspen/low-bush cranberry	N/A	N/A	26	17	6-28	5.12	26.25
d2	aspen-white spruce/low-bush cranberry							
	aspen	N/A	N/A	16	16	10-19	2.55	6.50
	white spruce	N/A	N/A	15	15	9-21	3.22	10.37
d3	white spruce/low-bush cranberry			7	19	13-26	4.75	22.57
e	white spruce	175	17.8	N/A	N/A	N/A	N/A	N/A
	balsam poplar	38	19.7	N/A	N/A	N/A	N/A	N/A
	aspen	58	21.4	N/A	N/A	N/A	N/A	N/A
f	white spruce	175	16.4	2	13	10-16	4.24	18.00
	balsam poplar	7	17.8	1	8	--	0	0
	aspen	12	19.8	1	11.0	--	0	0
f1	balsam poplar-aspen (white birch)/horsetail							
	white birch	N/A	N/A	3	8	7-9	1.15	1.33
f2	balsam poplar-white spruce/horsetail							
	balsam poplar	N/A	N/A	1	8	--	0	0
	white spruce	N/A	N/A	2	13	10-16	4.24	18.00

Ecosites and Ecosite Phases		Beckingham and Archibald (1996)		Aurora Mine[a]				
		Number (n)	Site Index at 50 Years	Number (n)	SI (at 50 yrs)	Range in SI	Std. Dev.	Variance
g	black spruce-jack pine/Labrador tea							
	black spruce	21	9.9	3	8	7-9	1.00	1.00
	jack pine	20	11.7	3	10	8-13	2.65	7.00
h	white spruce-black spruce/Labrador tea							
	white spruce	35	12.9	2	8	6-9	2.12	4.5
	black spruce	15	9.5	1	7	--	0	0
i1	treed bog (black spruce)	32	9.8	31	8	3-23	3.82	14.58
j1	treed poor fen (black spruce and larch)							
	black spruce	9	10.4	9	8	5-11	1.94	3.78
	larch	11	8.3	9	15	10-22	4.15	17.25
k1	treed rich fen (larch)	5	7.3	18	13	8-17	2.59	6.68

[a] Site Index values presented here are the average of the primary tree species occurring in each polygon. This is meant to provide an approximate level of overall ecosite phase productivity.

Table B.8
Landscape and Soil Diversity in Natural Lands

LANDSCAPE			SOIL			
Geological Material	**Surface Expression**	**Capability**	**Surface Expression**	**Subgroup**	**Moisture Regime**	**Capability**
Eolian Sands	Dunes, 5 to 15 m relief. Undulating plains, <15% slopes, <5 m relief. No aspect effects.	1	Dunes, 5 to 15 m relief. Undulating plains, <15% slopes, <5 m relief. No aspect effects.	Dystric Brunisols	Subxeric, Submesic	4
				Gleyed Dystric Brunisols	Subhygric	3
				Orthic and Peaty Gleysols	Hygric [a]	4
Fluvial (recent) sandy, silty, gravelly	Floodplains, terraces, dissected by meander Scars, <5% slopes, <5 m relief. No aspect effects.	1	Floodplains, terraces, dissected by meander scars, <5% slopes, <5 m relief. No aspect effects.	Orthic Regosols	Mesic	2
				Gleyed Regosols	Subhygric	1
				Orthic and Peaty Gleysols	Hygric [a]	4
Glacio-fluvial sandy, gravelly	Meltwater channels, gently undulating, ridged, <9% slopes, <5 m relief. No aspect effects.	1	Meltwater channels, gently undulating, ridged, <9% slopes, <5 m relief. No aspect effects.	Dystric & Eutric Brunisols	Submesic, mesic	3, 4
				Gleyed Brunisols	Subhygric	2, 3
				Orthic and Peaty Gleysols	Hygric [a]	4
Glacio-lacustrine clayey	Plains, <5% slopes, <2 m relief. No aspect effects.	1	Plains, <5% slopes, <2 m relief. No aspect effects.	Orthic Gray Luvisols	Mesic	2
				Gleyed Gray Luvisols	Subhygric	1
				Orthic and Peaty Gleysols	Hygric [a]	4
Morainal loamy to clayey	Undulating to rolling 5 to 30% slopes, 5 to 50 m relief. Minimal aspect effects.	1 to 2	Undulating to rolling 5 to 30% slopes, 5 to 50 m relief. Minimal aspect effects.	Orthic Gray Luvisols	Mesic	2
				Gleyed Gray Luvisols	Subhygric	1
				Orthic and Peaty Gleysols	Hygric [a]	4
Rough Broken Variable	Steeply sloping river banks, 16-70% slopes, 5 to 100 m relief. Unstable. Aspect effects.	2 to 5	Steeply sloping river banks, 16-70% slopes, 5 to 100 m relief. Unstable. Aspect effects.	Luvisols, Brunisols, Regosols	Submesic, mesic	3, 4
				Gleyed Soils	Subhygric	2, 3
				Gleysols	Hygric [a]	4
Organic fibric, mesic and humic peats	Bogs - level, high water table.	1	Bogs - level, high water table.	Typic and Terric Mesisols and Fibrisols	Subhydric	5
	Fens - level, high water table	1	Fens - level, high water table	Typic and Terric Mesisols and Humisols	Subhydric	5

[a] Hygric aerated is Class 2 or 3, reduced is Class 4.
Source: Leskiw and Moskal 1997a,b.

Table B.9
Landscape and Soil Diversity on Reclaimed Lands

LANDSCAPE			SOILS		
Reconstruction Material	**Surface Expression**	**Capability**	**Soil Type**	**Moisture Regime**	**Capability**
Overburden with soil Capping	Side walls, 16 to 40% slopes, 5 to 100 m relief. Aspect effects.	2 to 3	Peat-mineral topsoil on overburden.	Mesic	3
				Subhygric	2
			Peat-mineral topsoil over subsoil on overburden	Mesic	2
				Subhygric	1
	Nearly level surfaces, <2% slopes, <5 m relief. No aspect effects.	1	Peat-mineral topsoil on overburden.	Mesic	3
				Subhygric	2
				Hygric [a]	4
				Subhydric, Hydric	5
			Peat-mineral topsoil over subsoil on overburden	Mesic	2
				Subhygric	1
				Hygric [a]	4
				Subhydric, Hydric	5
Tailings sand with soil capping	Side walls, 16 to 40% slopes, 5 to 100 m relief. Aspect effects	2 to 3	Peat-mineral topsoil on tailings sand	Submesic, Mesic	3
				Subhygric	2
			Peat-mineral topsoil over subsoil on tailings sand	Submesic, Mesic	3
				Subhygric	2
	Nearly level surfaces, <2% slopes, <5 m relief. No aspect effects.	1	Peat-mineral topsoil on tailings sand	Mesic	3
				Subhygric	2
				Hygric [a]	4
				Subhydric, Hydric	5
			Peat-mineral topsoil over subsoil on tailings sand	Mesic	2
				Subhygric	1
				Hygric [a]	4
				Subhydric, Hydric	5

[a] Hygric aerated is class 2 or 3, reduced is Class 4.
Source: Leskiw and Moskal 1997c,d.

B4.0 LITERATURE CITED

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APPENDIX C

ACTS, REGULATIONS, POLICIES AND GUIDELINES RELEVANT TO REVEGETATION AND RECLAMATION IN THE OIL SANDS REGION, DATED JULY 1997

ACTS, REGULATIONS, POLICIES AND GUIDELINES RELEVANT TO REVEGETATION AND RECLAMATION IN THE OIL SANDS REGION, DATED JULY 1997

Prepared by Chris Hale, Alberta Environmental Protection

Acts and Regulations

- The Forest Act and associated Regulation
  - The Timber Management Regulations and,
  - Regeneration Survey Manual, with the 1997 Deciduous Amendment.
- Alberta Environmental Protection and Enhancement Act, and Regulations
  - The Conservation and Reclamation Authority, and associated Operating Conditions for each Mine.
- The Public Lands Act, and Regulations
  - The Mineral Surface Lease Letter of Authority, and associated Operating Conditions for each Mine.
- The Canada Seed Act

Policies and Guidelines, as Authorized by Legislation

- Fort McMurray-Athabasca Oil Sands Subregional Integrated Resource Plan.
- Recommended Native Grasses and Legumes for Revegetating Disturbed Lands in the Green Area.
- Forest Conservation Strategy.
- Canadian Framework of Criteria and Indicators for Sustainable Forest Management, and Defining Sustainable Forest Management, A Canadian Approach to Criteria and Indicators, from the Canadian Council of Forest Ministers.
- Forest Site Interpretation & Silvicultural Prescription Guide for Alberta.
- The Alberta Timber Harvest Planning and Operating Groundrules.
- C & R/97-1 Conservation and Reclamation Guidelines for Alberta.
- C & R/IL/96-1 Land Capability Classification for Forest Ecosystems in the Oilsands Region.
- C & R/95-1 Conservation and Reclamation Code of Practice for Alberta.
- Guidelines for the Preparation of Applications and Reports for Coal and Oil Sands Operations., Alberta Land Conservation and Reclamation Council, 1991.

APPENDIX D

RESEARCH ON PLANT VARIETIES

RESEARCH ON PLANT VARIETIES

Prepared By: Leanard Barnhardt and Narinder Dhir, Alberta Environmental Protection

D1.0 OVERVIEW

Research on plant varieties provide an opportunity to develop exotic or hybrid stock that may out perform native varieties in certain aspects. To conduct research on exotic or hybrid plant varieties, the proponent must submit the proposed trial, with a complete description of how it will be done and what is to be proven, to the Land and Forest Service, Forest Management Division, Genetics Section for approval. Research that meets approved design parameters will likely be approved for research.

Exotic, clonal or hybrid plant varieties used in experimental trials will not be accepted for reclamation certification until research proves the acceptability of those plants to the standards set by the Land and Forest Service. A more descriptive listing of the requirements for exotic forest tree species, clonal forestry, hybrid varieties and plant with novel traits is provided below.

D1.1 GENERAL INFORMATION REGARDING EXOTIC, CLONAL OR HYBRID PLANT VARIETIES AND PLANTS WITH NOVEL TRAITS

Exotic Forest Tree Species

- Promising Species
  - Siberian Larch *Operational testing stage*

    (Raivola Siberian Larch more suited for the north)
  - Scots Pine *Research testing phase*

    (Southwestern Siberian seed sources are more promising)
- No exotic tree species is approved for reforestation in Alberta at present. Issues of concern are:
  - Must not be injurious to forest health,
  - Insufficient test data,
  - Long-term insect/disease concerns,
  - Genetic base population, and
  - Ecological succession and evolutionary biology of the exotic forest.

Clonal Forestry

- Definition:
  - A forest regeneration method in which clones or genetically identical trees are deployed and tended to produce forest crop.
- Advantage:
  - Highly specialized and productive varieties can be developed.
- Disadvantages:
  - Risks associated with reduced genetic diversity,
  - Requires continuing research and development efforts to replenish clones on periodic basis,
  - Requires site specific and more intensive silviculture practice, and
  - Concerns about the progeny of clonal forest.

Hybrid Varieties

- Definition:
  - F1 populations derived by crossing selected clones, varieties, natural populations (or species) that are genetically dissimilar.
- No applicable example in Alberta forestry at present.

Plants With Novel Traits (PNT)

- Definition:
  - Plant variety/genotype possessing characteristics that demonstrate neither familiarity nor substantial equivalence to those present in a distinct stable population of a cultivated species of seed in Canada and that have been intentionally selected, created or introduced into a population of that species through specific genetic change.
- Familiarity:
  - The knowledge of the characteristics of a plant species and experience with the use of that plant species in Canada.

- Substantial Equivalence:
  - The equivalence of a novel trait within a particular plant species, in terms of its specific use and safety to the environment and human health, to those in the same species, that are in use and generally considered as safe in Canada, based on valid scientific rationale.

Test Criteria and Considerations for PNT

Familiarity:

- Species
- Trait introduced
- Method of introduction
- Cultivation practice

Substantial Equivalence:

- Altered weediness potential
- Gene flow to related species
- Altered plant pest potential
- Potential impact on non-target organisms
- Potential impact on biodiversity

APPENDIX E

ECOLOGICAL DIVERSITY MONITORING FRAMEWORK, DRAFT #6, REPARED FOR THE BIODIVERSITY MONITORING WORKING GROUP (AUGUST 1997)

Ecological Diversity Monitoring Framework

Draft For Discussion (#6)
August, 1997

Prepared for the Biodiversity Monitoring Working Group

Richard Schneider
R. R. 2, Tofield, AB.
T0B-4J0
403-662-4233
rschneid@gpu.srv.ualberta.ca

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SUMMARY

This paper outlines a framework for monitoring ecological diversity within the forested regions of Alberta. The emphasis is on detecting changes associated with industrial use of the forest. The unit of concern is the complete forest ecosystem, including both terrestrial and aquatic habitats.

The initial section of the paper describes the international, national, and provincial context for the framework. The rationale for the framework is then discussed, and the following objectives are listed:

- To detect changes in ecological diversity that exceed the range of natural variation, across a range of spatial and temporal scales.
- To provide an "early warning" of impending irreversible changes.
- To provide reports to the public on the status of ecological diversity in Alberta in a timely and accessible manner.
- To meet Alberta's national and international commitments for monitoring biodiversity.
- To provide data consistent with the requirements of forest certification programs.

The remainder of the paper outlines the actual framework and topics relevant to its implementation. The framework has four components:

- Remote sensing.
- Large-scale sampling network.
- Endangered/threatened species monitoring program.
- Research program.

The large-scale sampling network is discussed in detail. A systematic network of fixed sample points across the entire forested region of the province is proposed. A preliminary list of elements to be sampled is presented, along with a description of sampling protocols. The need for reference areas (i.e., controls) is discussed, and the Chinchaga watershed, Liege River watershed, and Caribou mountains are proposed as candidate reference areas.

It is proposed that a single agency run the monitoring program, with ongoing direction provided by an administrative committee comprised of representatives from the government, agencies that fund the program, and technical experts. It is suggested that funding for the program be derived from stumpage fees and similar mechanisms from all industries that use the forest.

E1. SCOPE

The program for monitoring ecological diversity outlined in this paper is intended to detect changes in ecological diversity within the forested regions of Alberta. The emphasis is on detecting changes associated with industrial use of the forest (e.g., forestry, oil and gas exploration and extraction, and mining). The unit of concern is the complete forest ecosystem, including both terrestrial and aquatic habitats.

E2. CONTEXT

E2.1 International

At the international level there are two initiatives with direct relevance to Canada and Alberta. These are the United Nations Convention on Biodiversity (i.e., Rio Convention; UNEP 1992) and the Montreal Process (i.e., Santiago Declaration (Canadian Forest Service 1995). Canada is a signatory to both documents. The Rio Convention focuses on strategies for conserving biodiversity, and includes explicit requirements for the monitoring of biodiversity (Article 7). The Montreal Process was established in 1994 to develop internationally agreed upon criteria and indicators for the conservation and sustainable management of temperate and boreal forests.

The United States currently spends 650 million dollars per year on environmental monitoring, including the monitoring of forest health (CENR 1997). The nation is in the process of combining all of its various monitoring programs into a single fully integrated framework (CENR 1997). The objectives of the new framework are to "identify environmental and ecosystem trends, relate these trends to their causes and consequences, and predict the outcomes of alternative future scenarios." (CENR 1997; p. 6). A fundamental premise of the framework is that "no single sampling design can efficiently provide all the information required to evaluate environmental conditions and to guide policy." (CENR 1997; p. 14). Consequently, the framework has three interrelated levels:

1. Remote sensing,

2. A regional sampling network, and

3. Intensive monitoring/research sites.

Levels one and two are intended to quantify the extent, distribution, condition, and rate of change of specific environmental variables over the entire land base. Level three is intended to determine the causes of changes noted in levels one and two and to develop and test predictive models. Integration, through the use of a standard set of core variables, standards for data collection, research, and modeling, is a key feature of the framework.

The United Kingdom has established an Environmental Change Network to:

1. Obtain comparable long-term data sets for major environmental variables that can be used to distinguish human-induced change from natural variation,

2. Identify and quantify environmental changes associated with human activities, and

3. Give warning of undesirable effects (National Environmental Research Council 1994).

The network currently consists of 50 sites throughout the United Kingdom, and is linked to integrated surveys that combine remote sensing and ground-based sampling. The network is operated by a consortium of 15 sponsoring organizations coordinated by the National Environmental Research Council.

Other notable examples of international environmental monitoring programs include the Global Terrestrial Observing System (UNESCO 1997) and the United Nations Economic Commission for Europe Integrated Monitoring Program (UNECE 1993). Most environmental monitoring programs were initiated in response to air and water pollution issues; however, many have since expanded in scope to incorporate the monitoring of biodiversity as well.

E2.2 National

Canada has made commitments relating to the monitoring of biodiversity in the National Forest Strategy (CCFM 1992), the Canadian Biodiversity Strategy (Environment Canada 1995), and the Rio Convention (UNEP 1992). The Canadian Biodiversity Strategy states: "Monitoring programs are required to detect and measure changes in biodiversity, to better understand functional linkages in ecosystems, and to evaluate the success or failure of biodiversity conservation and sustainable use policies and programs." (Environment Canada 1995). In response to these commitments, the Canadian Council of Forest Ministers (CCFM) has produced a set of criteria and indicators for the sustainable management of Canada's forests, including indicators for biodiversity and ecosystem function (Canadian Council of Forest Ministers 1995).

There are currently three main programs involved in monitoring biodiversity at the national level in Canada. The first is Environment Canada's National Environmental Indicators Program (EC 1997). This program monitors national-level indicators of sustainable forest management, including timber harvest levels, natural disturbance trends, and regeneration after harvest. Indicators of biodiversity are planned, but have not yet been implemented (EC 1997). The second national initiative is an annual report produced by the Canadian Forest Service entitled *The State of Canada's Forests* (Canadian Forest Service 1996). This report covers a range of issues related to Canadian forests and includes data on some of the indicators established by the CCFM. The final initiative, begun in 1994, is the Environmental Monitoring and Assessment Network (EMAN) (EMCO 1996). The goal of this initiative is to understand what changes are occurring in Canadian ecosystems and why. To answer these questions long-term multidisciplinary information is being gathered within a research context at a network of 78 sites across the country. The research sites

are all independently funded and managed and the role of EMAN is primarily one of coordination and integration.

Monitoring is also part of the mandate of the national parks (Woodley 1997) and the Model Forest Program (CFS 1997); however, only some sites have implementing formal monitoring programs (e.g., Yoho (YNP 1997) and Kejimkujik (Drysdale and Beattie 1995)).

Two forest certification programs are being advocated in Canada, one by the Canadian Standards Association (Canadian Standards Association 1996) and the other by the Forest Stewardship Council (Elliott and Hackman 1996). They are not intended to serve as national monitoring programs; however, monitoring is an integral component of both programs. The indicators relating to biodiversity in these programs are, in general, consistent with the criteria and indicators proposed by the CCFM (Canadian Council of Forest Ministers 1995).

E2.3 Provincial

The situation with respect to the monitoring of biodiversity in Alberta is atypical relative to most other jurisdictions in that the government is in the process of transferring much of the responsibility for monitoring to industry. Several forestry companies have produced discussion papers concerning biomonitoring programs they have under consideration (Bonar 1995; Doyon and Duinker 1997; Gilmore 1997; Rabik and Larson 1997).

The government will continue to play a role in monitoring; however, the nature of that role is still being determined (H. Stelfox, pers. comm.). Currently, the Wildlife Management Division of Alberta Environmental Protection monitors the status of wildlife (primarily non-fish vertebrate species) for planning and management purposes. This activity also supports the department's policy commitment to publicly report on the status of wildlife every five years. A Biodiversity Species Observation Database is used to store and evaluate observations of species from various sources throughout Alberta. Particular attention is given to the collection and analysis of population data for species that are, or may be, at risk of permanent decline. The Biodiversity Species Observation Database and other data sources are used to help determine more formal threatened and endangered species designations for Alberta and Canada. The Alberta Natural Heritage Information Centre, managed by the Recreation and Protected Areas Division of Alberta Environmental Protection, tracks occurrences of rare features of provincial significance, primarily plant and animal species, but also geological and cultural features.

In the non-government sector, the Federation of Alberta Naturalists maintains provincial natural history databases which include: (1) the Alberta Breeding Bird Atlas, (2) Spring (May) Species Counts for plants & birds, (3) Alberta Birdlist observations and (4) Christmas Bird Count results (as reported in the Alberta Naturalist). These data are primarily from amateur naturalist sources.

The Foothills Model Forest (CFS 1997) has expressed an interest in becoming involved in the monitoring of biodiversity (e.g., through the development of this framework), as have Jasper National Park and Wood Buffalo National Park (P. Achuff, pers. comm.; N. Stolle,

pers. comm.). There are three EMAN sites in the forested regions of Alberta: the Meanook Biological Research Station, the Terrestrial and Riparian Organisms, Lakes and Streams (TROLS) study area, and South Waterton Biosphere Reserve. Additional ecological research, much of it industry sponsored, is being conducted at sites that are not part of EMAN.

E3. RATIONALE

E3.1 Monitoring As An Audit Process

The maintenance of ecological diversity has become a central goal of forest management in Alberta (Alberta Forest Conservation Strategy Steering Committee 1997) and across North America (Hunter 1991; Everett 1993; Grumbine 1994). Consequently, the government (on behalf of the public) and industry (as part of its internal audit process) must monitor forest ecosystems to ascertain whether or not the goal of maintaining ecological diversity is being met as resources are being extracted (Noss 1990; Christensen et al. 1996; Alberta Forest Conservation Strategy Steering Committee 1997).

E3.2 Monitoring As Part Of An Adaptive Approach To Resource Management

Because of gaps in our understanding of ecological systems, among other factors, the outcome of resource management strategies is generally uncertain (Hunter 1991; Walters and Holling 1990). Therefore, management procedures must be continually modified in response to feedback from the system in order to achieve management objectives (Kessler et al. 1992; Everett 1993). The implementation of such an adaptive approach to management requires a monitoring program to provide the necessary feedback and a research program to determine the cause of any problems that are noted and to provide options for mitigation (Ringold et al. 1996). The monitoring program should incorporate a predictive element so that irreversible deleterious changes, such as the extirpation or extinction of a species, can be prevented while it is still possible (Ligon and Stacey 1996; CENR 1997).

E3.3 Monitoring As An Alternative To A Prescriptive Regulatory Framework

Without a rigorous monitoring program in place it is unlikely that public acceptance of a flexible approach to forest management, such as ecosystem management, would be maintained (Grumbine 1994). The imposition of a rigid regulatory framework would become increasingly more likely.

E3.4 Monitoring To Fulfill National And International Commitments

Monitoring is required to fulfill Alberta's national and international commitments, as described in Section 2.

E3.5 Monitoring As Part Of Forest Certification

Monitoring is a prerequisite for forestry companies seeking to ensure market security through certification programs (Elliott and Hackman 1996). Monitoring is an integral component of both the Canadian Standards Association (Canadian Standards Association 1996) and the Forest Stewardship Council certification programs (Elliott and Hackman 1996).

E4. OBJECTIVES

E4.1 Monitoring

The objectives of the monitoring program are to:

- Detect changes in ecological diversity that exceed the range of natural variation, across a range of spatial and temporal scales.
- Provide an "early warning" of impending irreversible changes.
- Provide reports to the public on the status of ecological diversity in Alberta in a timely and accessible manner.
- Meet Alberta's national and international commitments for monitoring biodiversity.
- Provide data consistent with the requirements of forest certification programs.

E4.2 Research

Research has an important adjunct role within the context of the monitoring framework. The objectives of the research component are to:

- Support the implementation of the monitoring program by providing insight into appropriate sampling design, sampling methodology, species selection, statistical analyses, and other related issues.
- Determine the cause of any changes in ecological diversity that are observed. This may entail short-term studies in response to specific problems, but should also include long-term research into ecological processes to provide a broader foundation for understanding changes.
- Provide management options for the mitigation of any deleterious changes that are observed.
- Develop the capability for avoiding deleterious changes by constructing predictive models based on research findings and data collected through the monitoring program.

E5. FRAMEWORK

E5.1 Introduction

Ecological systems can be characterized by three key attributes: composition, structure, and function (Noss 1990). Composition refers to the constituent parts of the ecosystem, both biotic and abiotic. Species are typically used to define the unique elements of the biotic component; however, the existence of local and regional variation in genotype must also be recognized (Noss 1990). Ecosystem structure refers to the spatial organization of the constituent parts of the system, including large-scale patterns. Ecosystem function refers to how the parts interact with each other. Variety and variability within these key attributes, across a range of spatial and temporal scales, constitute ecological diversity (Naiman et al. 1993).

The key objective of the monitoring framework is to detect changes in ecological diversity. However, because the forest landscape is dynamic it is not change per se that must be detected, but changes that exceed the range of natural variability (Swanson et al. 1993; Frelich and Reich 1995; Christensen et al. 1996; Hecnar and M'Closkey 1996). This implies that the monitoring framework must not only provide data for determining the mean values of ecological attributes, but for characterizing variances as well. Furthermore, the "base case" that is used as a reference when making comparisons (see below) will have to be well characterized in terms of the expected range of natural variability.

The issue of scale is critical to the assessments that are made. The range of natural variation is scale-dependent (both temporally and spatially), so measurements must be made across multiple scales to fully quantify it (Lord 1990; Noss 1990; Knopf and Samson 1994; Steen et al. 1996). The impact of industrial activity is also scale-dependent, and assessments made at small scales cannot be directly extrapolated to larger scales. For example, the cumulative impact of many local changes may combine synergistically to cause unexpected and significant changes at the regional level, or they may simply blend into the background of natural variation. Only integrative measurements taken at large scales will be able to discern the true outcome (Bohning-Gaewse et al. 1993; Brown et al. 1995; Hecnar and M'Closkey 1996).

Two types of "base case" (i.e., control) are available as a reference for the monitoring program, each with its own set of benefits and drawbacks. The first is the industrial land base itself. Given that large-scale forestry is a relatively recent phenomenon in Alberta, excepting the Eastern Slopes, most sampling will initially occur in unharvested forest patches. Consequently, it will be possible to gain an understanding of the initial state of the system, including an estimate of the range of natural variation, based on the initial years of sampling and reference to historical inventory data. Such a control is desirable because of its direct spatial correspondence to the treatment area. The drawback of this control is that it only provides a "snap-shot" of the system at a specific period of time. Eventually, most of the sample points in the industrial land base will be harvested or

otherwise impacted. The indirect effects of regional forest harvesting may affect sample points in an even shorter period of time.

The second type of "base case" is a contemporary control based on a system of fixed reference (benchmark) areas and parks. Contemporary controls will increase in importance, relative to the static controls, as climate change and the establishment of roads begin to exert a significant influence on the landscape and as different types of data are required because of changing societal priorities (Kurz et al. 1995). The drawbacks of this type of control are that they are spatially separated from the treatment areas and that they all have been impacted to some extent by roads, fire suppression, and other human influences.

Multiple strategies for collecting data will be necessary to address all of the objectives of the monitoring framework. The following are the key components:

- Remote sensing.
- Large-scale sampling network.
- Endangered/threatened species monitoring program.
- Research program.

E5.2 Remote Sensing

Conservation ecologists contend that biota are often adapted to structural attributes of forest landscapes such as the size, age, juxtaposition, and interspersion of forest patches (Hunter 1993; Bunnell 1995). If a relationship between the viability of biotic populations and patch metrics does exist, then changes to landscape patterns through industrial use of the forest may lead to altered biodiversity (Hunter 1993; Bunnell 1995). For this reason the long-term monitoring of landscape metrics should be a key component of the monitoring framework.

Data collected through remote sensing technologies (both satellite and aircraft) are well suited to measuring spatial metrics dealing with patch size, shape, and general composition. They provide an opportunity for monitoring at the largest spatial scales without the need for subsampling, though sampling at these spatial scales generally precludes fine-scale measures (e.g., the composition or abundance of animal species). Once these photogrametric data are processed and housed within a Geographical Information System (GIS), it becomes possible to characterize the forest landscape using a host of metrics such as provided by FragStats (McGarigal and Marks 1994).

Another key role of remote sensing is to track changes in the supply of vegetative communities, particularly those that are rare or are likely to be lost through industrial use of the forest (e.g., older age classes). For most forested regions, fine-scale classification of vegetative communities is currently based on Alberta Vegetation Inventory (AVI) polygons (DEP 1994a) but eventually it may be possible to use an ecological classification

system (e.g., ecosite phase; DEP 1994b). The mean area of each community type, and the temporal variability of this mean, across a range of spatial scales, are the key summary measures to be made. The spatial distribution of the community types should also be described. A good example of the utility of AVI-type inventories is for the detection of the unmixing of hardwood/softwood species that may be caused by certain harvesting and silvicultural practices.

Many of the aforementioned analyses are already done by forestry companies, but there is a need for the analyses and reporting to be done in a uniform and consistent manner so that meaningful comparisons across space and time can be made. The data should be updated on a regular (5-10 year) basis so that an analysis of trends can be done.

E5.3 Large-Scale Sampling Network

A large-scale sampling network will be required for ground-truthing the measurements made through the remote sensing program and for collecting various types of data that cannot be collected remotely. Because this component of the monitoring framework has received little attention to date, and has a great need for an integrated design, it will be discussed in detail below.

E5.3.1 General Sampling Design

The level of detail of the sampling network will necessarily be fairly coarse given the immense spatial scale involved and limitations on the financial resources available. There will be a tradeoff between the number of sample points that can be established and the amount of data that can be collected at each point.

A sampling design based on the systematic placement of fixed sample points is arguably the best approach to take, primarily because of its flexibility. With this approach, stratification takes place at the analysis stage, instead of prior to sampling. Therefore, regardless of the landscape unit that may be of interest (e.g., Natural Subregion, forest management area, etc.), or the type of industrial impact being investigated (forest harvesting, oil and gas exploration, etc.), the distribution of sample points will always be appropriate. Given the long time frame of the monitoring program, maintaining options is a major consideration. Experience has shown that our delineation of landscape units changes continually over time, as new data are gathered, new questions arise, and new management designations are applied (Department of Environmental Protection 1994a,b). From a logistical perspective, a systematic design is also efficient to implement, as it is not necessary to spend time finding sample points that meet specific criteria. Finally, data arising from a systematic design lends themselves to wide applicability for future scientific research, the nature of which we may not even anticipate at the present time.

The major drawback of a systematic sampling design is that rare vegetative communities will not be well represented. It should be possible to achieve a sample size that will adequately represent the major successional trajectories of forests in the province, but rarer stages will undoubtedly be missed. These communities will therefore need to be emphasized in the remote sensing component of the monitoring framework (Section 5.2).

High profile communities could also be monitored through specialized programs, along the lines of endangered species monitoring (Section 5.4).

An alternative approach to the systematic sampling design would be to initially stratify the landscape based on an ecological classification scheme such as the Natural Regions of Alberta (Department of Environmental Protection 1994a,b). In theory this would provide a more balanced sampling of the different types of vegetative communities and may increase the statistical efficiency of the monitoring program (Bourdeau 1953; Scott et al. 1981). However, there are several problems with this approach as well:

- Ecological classifications to the level of ecosite phase have only been completed for a small fraction of the province, and there are no plans to complete the classifications in the near future.

- Many rare vegetative communities, such as those associated with older age classes of forest, are transient phenomena that move around the landscape over time (Frelich and Reich 1995). Furthermore, different vegetative communities can occur on the same physical site, depending on the disturbance history and other factors (Frelich and Reich 1995). Consequently, as disturbances alter the landscape, the initial scheme of stratification will be lost (given a fixed array of sample points).

- An increase in statistical efficiency may not apply for all analyses. For example, given a limited number sample points overall, a distribution of points based on ecological criteria may decrease the statistical power for contrasting landscapes based on non-ecological criteria such as Forest Management Agreement (FMA) boundaries.

Other sampling designs, such as randomly selected sample points, also exist. The decision on which design to implement should be based on a detailed statistical power analysis, using the best available estimates for the means and variances of the various data measurements (Murtaugh 1996; Thomas 1996). A power analysis will also be required to determine the overall number of sample points in the system. As a ballpark estimate, it would seem that at least one sample point per township will be required to provide adequate coverage. This translates into approximately 3,800 points for the entire Green Zone of the province.

E5.3.2 General Sampling Protocol

Each sample point in the systematic grid of points would be permanently identified and located by a set of Geographic Positioning System (GPS) coordinates. It can be anticipated that access to most points will have to be by helicopter. Sampling would be conducted by a team of two or four personnel using a fixed protocol (Scott et al. 1981; Oliver and Beattie 1993; Oliver and Beattie 1996). The local variance in the attributes that are measured would be estimated by sampling along linear transects that extend out from the central point and in quadrats of fixed size and at a fixed distances from the

central point. An areal photograph could be taken of the site to record vegetative structure and local physiography.

Given adequate sampling intensity it should be possible to estimate the mean and variance of sampled attributes for the local region surrounding each sample point. By pooling data from many points it should also be possible to estimate the mean and variance of the sampled attributes at very large scales. What is lacking is link between the two scales. Specifically, we must understand what happens between the 100-200 meters that surround a sample point and the ten kilometers that separate adjacent sample points (given one point per township). It would be possible to address this issue by extending the sampling zone to the intermediate scale on a subset of the sampling points. For example, at every tenth sample point additional measurements could be taken at fixed intervals out to perhaps a few kilometers from the central point. Similarly, for the temporal scale, a subset of points could be resampled every year to provide an estimate of the annual variance, and provide the context for interpreting fluctuations that are observed in the sites that are sampled less frequently.

E5.3.3 Sampling Protocol For Aquatic Systems

Monitoring of aquatic systems is somewhat problematic using a systematic sampling design because most sample points will fall in terrestrial habitats. One solution would be to sample the water source closest to the systematic sample point. It may also be desirable to take additional measurements from selected larger streams. Together with data from the systematic grid, the data from larger streams could be used provide integrated assessments of selected watersheds.

E5.3.4 Sampling Elements

The selection of the elements to be monitored is central to the design of the monitoring program. For large-scale monitoring it is desirable to standardize the types of data that are collected (CENR 1997). This will increase the power of the program to detect changes, increase its cost effectiveness, and facilitate the reporting of the results in a consistent and meaningful manner. Standardized monitoring will also help ensure that changes that are widespread are not erroneously attributed to localized land use practices.

The following is a preliminary list of the core elements that should be measured at each sample point. Abiotic elements are included for later incorporation into multivariate statistical analyses. The biotic elements are intended to provide full coverage of ecological diversity, including composition, structure, and function. Note that many additional measurements pertaining to ecological structure, particularly at larger scales, are made through the remote sensing component of the framework (Section 5.2).

Abiotic:

- Elevation
- Slope

- Aspect
- Soil (nutrient levels and selected physical, chemical, and biological properties)
- Local physiography
- Distance to nearest linear disturbance (e.g., road, seismic line)
- Presence of industrial facilities (e.g., wellsite) within a given radius

Terrestrial flora:

- Composition of vegetative overstorey and understorey using Ecosite Phase and maturity class classification
- Density of snags
- Amount and distribution of coarse woody debris
- Percentage of forest cover within a defined radius
- Percent green tree retention (in recently disturbed sites)
- Estimated abundance of indicator species and composition of indicator assemblages

Terrestrial fauna:

- Estimated abundance of indicator species and composition of indicator assemblages
- Estimated abundance of selected exotic species

Aquatic systems:

- Abiotic measures, including: dissolved oxygen content, amount of large woody debris and stage of rot class, silt loading (from road construction), and temperature and light penetration (via automated long-term sensors)
- Composition of emergent vegetation, larger aquatic invertebrates, small fish species, and benthic fauna

Ecological function (our understanding of ecological function is limited and further research will be required to better define what should be monitored):

- Growth rate of trees
- Nutrient cycling

- Successional trajectory
- Natural disturbance events:
  - Large-scale measures including rate of disturbance by type (e.g., forest harvesting, seismic exploration, fire, insect outbreak, disease) and percent of all disturbances due to industrial use
  - Small-scale measures including tree fall rates and gap initiation
- Hydrology

The preceding list of elements is fairly general. A considerable amount of effort will be required by the agencies involved in implementing the program to define the specific elements to be monitored. These decisions should be based on scientifically defensible principles to ensure the greatest probability of achieving the goals of the program and to help secure public acceptance of the program. Economic factors will also need to be considered at some point, providing a "reality-check" on what can realistically be implemented. A workshop setting may be best suited for the simultaneous consideration of all perspectives. Participants should include researchers with a broad range of technical expertise and representatives from the various agencies that will ultimately be responsible for implementing the program.

Given the vast number of species existing in forested ecosystems, and the difficulties inherent in monitoring them, the use of surrogate measures for ecological composition will be unavoidable. Indicator species are typically used for this purpose (Pearson 1994; CCFM 1995), though there is much concern associated with their use (Van Horne 1983; Block et al. 1987; Landres et al. 1988). The indicator species that are chosen should represent a broad range of taxonomic groups so that the assessment of composition is as comprehensive as possible. Too narrow a focus during the selection of the indicators will weaken the program and foreclose future options (in the same way that a pre-stratified sampling design is limiting; Section 5.3.2). The following is a list of key criteria that are desirable in species to be used as indicators for monitoring biodiversity (Noss 1990; Pearson 1994; Bonar 1995):

- Distributed across all of the regions to be monitored
- Potential to act as a surrogate for other similar species
- Easy and relatively inexpensive to monitor
- Preexisting data available
- Biology of the species is reasonable well understood
- Sensitive to industrial impacts (able to provide an early warning of problems)

- Sufficient sample size for monitoring

- Stable population dynamics

To circumvent the deficiencies of indicator species, the monitoring of species assemblages should be attempted wherever possible (Kremen 1992). For example, instead of monitoring the abundance of a single species of bird, the presence of all birds along a linear transect (based on vocalizations) could be recorded. Statistical techniques for analyzing changes in such species assemblages have been developed for the analysis of Breeding Bird Survey data and other similar datasets (Bohning-Gaese et al. 1993; James et al. 1996; Flather and Sauer 1996). Such analyses provide a much broader assessment of species diversity than the weak extrapolations provided by individual indicator species.

The monitoring of genetic diversity is even more difficult than the monitoring of species diversity. It is unlikely that direct assessments can be made for more than a few species, such as tree species that are genetically manipulated as part of silvicultural programs. Assessments for other species will have to be indirect, based on the status of population sizes and distributions. Because techniques for the analysis of genetic diversity are advancing rapidly, it would be prudent to archive selected samples for potential analyses in the future (Hedrick and Miller 1992).

E5.4 Rare/Endangered Species Program

Rare and endangered species have a high public profile and must be incorporated into the monitoring framework. However, because of their rarity they are extremely difficult to monitor and specially designed programs are required for the task (Green and Young 1993; Kunin and Gaston 1993). It would be most efficient to integrate the monitoring of these species into the individual recovery plans that are being developed for endangered species in Alberta by the government and various stakeholders.

E5.5 Research program

There are many university, industry, and government research initiatives in Alberta dedicated to sustainable forest management (SFMNCE 1997). It would be most efficient to address the research needs of the monitoring program (Section 4.2) through these existing programs, rather than establishing a new program. However, it will be necessary to develop an efficient management structure to coordinate the research efforts and to ensure that all objectives are achieved in a timely manner. The use of the Sustainable Forest Management Network of Centers for Excellence (SFMNCE 1997) should be explored for this purpose. If this organization proves too unwieldy it may be necessary for the agencies that implement the monitoring program to develop their own management entity to oversee and coordinate monitoring-related research.

In addition to its supportive role, research can also be used to directly monitor certain elements of ecological diversity. Studies that compare the effects of various land-use practices to the effects of natural disturbances (Niemela et al. 1993; Siitonen and Martikainen 1994) can be construed as a form of monitoring, albeit, at small spatial and temporal scales. However, the data from these studies is most useful for advancing our understanding of ecological processes, rather than its direct use for monitoring. While every bit of information helps, small-scale research studies are no substitute for dedicated long-term monitoring of the cumulative effects of industrial practices over the entire land base.

One of the key deficiencies of the monitoring program is its lack of predictive power. Because of lags in many ecological processes, and various threshold phenomena, changes may not be detected until a critical state has been reached (With and Crist 1995; Brawn and Robinson 1996; Ligon and Stacey 1996). Therefore, as part of the research program, models based on research findings and data from the monitoring program should be developed to improve our ability to predict and mitigate negative consequences of industrial impacts before they become critical (CENR 1997).

E6. IMPLEMENTATION

E6.1 Administration

While multiple agencies will be involved in developing and funding the monitoring framework, it would be most efficient to establish a single entity to run the program (Scott et al. 1981). This would ensure that measurements and analysis are completely standardized, and it should be more cost effective than having each agency develop and run a small-scale program on its own. Furthermore, running the program at arm's length from the industry partners that fund it may be critical in obtaining public acceptance of the program and its results.

The organization that runs the monitoring program would be responsible for the following tasks:

- Collecting data from the large-scale sampling network, based on a defined protocol.
- Acquiring forest inventory updates in GIS format from industry and government sources as they become available, along with updated satellite images as required. Proprietary inventory data would be kept confidential.
- Summarizing the data and conducting specified analyses.
- Producing an annual report of the results.
- Storing the data and maintaining an Internet web site to provide access to it.
- Archiving samples.

- Running a quality control program to ensure that sampling and other operations continually meet required standards.

Ongoing direction, with respect to sampling protocols, data standards, and issues pertaining to funding, would be provided to the monitoring organization by an administrative committee. This committee would be comprised of representatives from the government, agencies that fund the program, and technical experts. The administrative committee would also provide direction for the research program associated with the monitoring program (Section 5.5).

The interpretation of the annual results of the monitoring program will require careful consideration. There may be profound changes in a single element of ecological diversity, or subtle changes in many. The range of natural variation may clearly be exceeded, or there may only be a progressive trend away from the mean. Changes may widespread or localized. Clearly, it will not be a simple matter to determine when sufficient change has occurred such that action is required, and such a determination is probably beyond the scope of the organization that does the monitoring. The best course may be to submit the results of the monitoring program to a scientific panel on a regular basis for detailed review. To maintain public acceptance of the monitoring program the recommendations of the panel should be made public. Implementation of the recommendations could be done through the administrative committee and by companies that are affected directly.

E6.2 Data Standards

Standardization of sampling protocols and methods of analysis will be critical for making meaningful comparisons across wide areas (Ringold et al. 1996; CENR 1997). The establishment of a technical working group for the development of these standards would be useful. To permit national and international comparisons, consideration should be given to the standards that are currently being developed for the monitoring of biodiversity by the EMAN initiative in Canada (EMCO 1996), and the National Environmental Monitoring Initiative of the United States (CENR 1997). Research may be required to determine the optimal methodologies for sampling and analysis where well-defined procedures have not yet been established.

Standards and defined protocols need to be established for the following elements of the program:

- Design of the large-scale sampling network and total number of sample points required (based on statistical power analyses; Section 5.3.1)

- Frequency of resampling individual sample points

- Spatial pattern of annual sampling. For example, a different Natural Region could be completely sampled each year, or a fraction of the points could be sampled across the entire land base each year.

- Data formats, particularly for GIS data

- Elements to be sampled (Section 5.3.4)

- Sampling methodology for each element (including length of transects, number and size of quadrats, measurements taken, etc.)

- Data summarization and analysis

It is also important that the monitoring framework be compatible with the criteria and indicators developed by the CCFM and used by forest certification programs (Appendix A). The monitoring framework as outlined, together with provincial-level data already collected by the government, should be sufficient to satisfy all of the CCFM indicators relating to ecological diversity and ecosystem function. Issues pertaining to data formats and reporting may still need to be addressed. National-level indicators (e.g., global carbon cycles) and socio-economic indicators are beyond the scope of the monitoring framework.

E6.3 Funding

Given the vast area that must be monitored, and the fact that access to most sample points will have to be by helicopter, it can be expected that the monitoring program will be an expensive undertaking. If industry is asked by the government to fund the program, then the most equitable approach would be to apportion the required fees based on resource usage per company. The stumpage fee system currently used by the forestry sector is an example of such an approach. In fact, it may be reasonable to direct some of the money currently collected from stumpage fees to the monitoring program, instead of to the productivity-related activities it is now used for. The cumulative impact of the oil and gas industry is on par with that of the forest industry and therefore its contribution to the monitoring program should also be on the same scale. Fees could be assigned based on the number of square meters of forest impacted by seismic exploration, drilling, and road building.

E6.4 Reference Areas

As discussed in Section 5.1, two forms of control, or "base case", are available for the monitoring program: a "snapshot" of the land base prior to industrial use, based on the initial years of sampling, and a contemporary control based on a system of ecological reference areas and parks. As both types of controls have serious deficiencies (see Section 5.1), it is critical that both be used together, if valid assessments are to be made.

The need for reference areas is documented in the Alberta Forest Conservation Strategy (Alberta Forest Conservation Strategy Steering Committee 1997) and it is recommended that the Special Places 2000 program be used as the mechanism for their establishment. However, the mandate of Special Places 2000 has been narrowly interpreted and the establishment of reference areas is not currently under consideration.

The lack of a provincial program notwithstanding, the selection of suitable reference areas may be fairly straight forward, because few options remain with regard to their placement. In northern Alberta, the Chinchaga watershed, the Liege River watershed, and the Caribou

Mountains have been proposed as potential reference areas. Though not entirely pristine, these regions contain large core areas that are not traversed by roads and have had minimal exposure to industrial activity to date. The forestry companies with cutting rights in these areas support their establishment as reference areas, though the oil and gas sector has not yet given its support. These three areas, together with Wood Buffalo National Park, would provide representation of seven Natural Subregions: Central Mixedwood, Wetland Mixedwood, Peace River Lowlands, Subarctic, Boreal Highlands, and Upper and Lower Foothills (Department of Environmental Protection 1994a,b). Three additional Natural Subregions would remain in need of representation: Dry Mixedwood, and the Upper and Lower Foothills in the southern half of the province. These latter three Subregions have already been heavily impacted by industrial use and, because of a high level of industrial commitment, there are few options available for the establishment of large reference areas. Creative solutions will be required, possibly involving the Little Smoky river and an expansion of Notikewan Provincial Park.

In addition to the issue of representation, candidate reference areas must also be capable of maintaining natural ecological processes over the long term (i.e., over 100 years). Because of this requirement the reference areas must be spatially fixed and industrial use must be prohibited within them. It is also necessary that the areas be large, so that they are not significantly influenced by industrial use of the adjacent forest, and so that ecological processes that operate at large spatial scales are maintained.

Two key processes that operate at large spatial scales are the movements of wide-ranging species and natural disturbance events such as fire. Even with fire suppression, large fire events still occur, as evidenced by the Mariana Lakes fire in 1995 (1,300 km^2). These infrequent catastrophic events may be qualitatively different than the many smaller disturbances that occur in intervening years and they may be one of the key processes that maintain ecological diversity in the boreal forest (Romme and Despain 1989; Greenberg et al. 1994; Bessie and Johnson 1995; Romme et al. 1995). The literature is vague with regards to specific size requirements for the maintenance of ecological processes, but most reports suggest that the areas must be greater than the largest disturbance event (Pickett and Thompson 1978; Baker 1992). For northern Alberta, this implies an area of several thousand square kilometers.

The final key requirement of candidate reference areas is that they contain a sufficient number of sample points to act as a statistically meaningful controls. If one sample point is established per township, then there would be 11 points per thousand square kilometers. This again implies that the reference areas will have to be several thousand kilometers in size, though statistical power analyses will be required to provide a more robust estimate.

Areas of several thousand square kilometers are possible for the Chinchaga, Liege, and Caribou Mountains, but may be difficult to establish elsewhere.

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APPENDIX F

A HISTORY OF TERRESTRIAL RECLAMATION IN THE OIL SANDS REGION

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A HISTORY OF TERRESTRIAL RECLAMATION IN THE OIL SANDS REGION

Prepared by:
Earl Anderson – Sycrude Canada Limited
Tom Coolern - Syncrude Canada Limited
Steve Tuttle – Suncor Energy Inc.
Carl Warner – AGRA Earth & Environmental Limited

F1. INTRODUCTION

Reclamation of terrestrial vegetation in the oil sands region has been ongoing since 1971 at Suncor and since 1976 at Syncrude. The majority of reclamation has occurred on relatively steep slopes (e.g., 27% to 40% slope angles) of tailings sand dykes and overburden dumps. The information presented in this section provides a summary of the methods used to reclaim these areas and the success of these methods.

F1.1 HISTORY OF LAND RECLAMATION TECHNIQUES AT SUNCOR

The current reclamation method at Suncor has been developed as a result of many years of scientific study, demonstration plots and serendipity. The original intent for implementing reclamation at Suncor in 1971 was to develop an erosion controlling cover of grasses. This goal was achieved through the placement of approximately 10 cm of peaty soil onto the reclamation site, tilling this soil into the overburden or tailings sand, then seeding to grass through use of a hydroseeder or seed drill. This method was successful in developing a self-sustaining cover of grass and legumes on the reclaimed areas. Although a sprinkler system was used at one time to assist the establishment of the grasses, this proved to be unnecessary, as the grass cover successfully developed under typical levels of precipitation received in the region.

However, the reclamation focus at Suncor has changed from one of erosion control only, to one where the development of a self-sustaining ecosystem in tune with the region has become the priority. One of the primary reasons for changing this goal was due to a shift in the type of soil being used as an amendment. Instead of utilizing peat alone, the peat layer along with a portion of the underlying soil was taken as a reclamation amendment. This provided for the addition of more fine components to the amendment, which allowed for a better quality soil to be placed on the reclamation site. In an attempt to eliminate areas where insufficient soil amendment was placed, the depth of application was increased to 20 cm.

In addition to the change in the depth of the amendment placed on a reclamation area, the amendment material source has also been altered. Muskeg soil had been excavated and placed in stockpiles for future use. Reclamation material needs were then drawn directly from these stockpiles. During the reclamation programs of 1983 and 1984, the source of the muskeg soil changed to deposits located in unmined areas where disturbance was minimal. The undisturbed material was excavated and placed directly on the reclamation site. The result of using partially frozen *in situ* pockets of topsoil was noteworthy

because native seeds and root fragments transferred with the soil became established and grew rapidly on the reclamation sites.

Seeding methods and mixtures have also changed. Hydroseeding of grasses and legumes on the reclamation areas is no longer included as part of the seeding program. Barley is now used as a nurse crop on all reclaimed sites because grasses proved to be over-competitive to trees, shrubs, and forbes developing on the reclamation sites. Aerial seeding is undertaken on new reclamation sites after which the areas are raked lightly with harrows. Raking of a shallow cover of soil on the barley seeds promotes early seed germination thus hastens erosion control for the newly reclaimed site. The barley cover does not hinder the development of the emerging vegetation but still functions in reducing erosion. Additionally, it leaves a stubble capable of trapping snow which is needed to protect the young tree seedlings during the winter.

A further refinement to the process of applying topsoil has been to excavate and haul soil building materials during the winter months when the *insitu* seed and roots are dormant. Spreading of the muskeg soil on the reclamation site is then completed in early spring. The usual result is the emergence of a variety of native woody stemmed plants, forbes, wildflowers and grasses. This prolific vegetative growth provides a erosion controlling cover which is diverse, in tune with the ecosystems found in the region, and easily capable of meeting the goals of the program.

Suncor has adopted, as part of its reclamation strategy, a planting program designed to provide a diverse mixture of woody stemmed species on the reclaimed areas. The species mixture includes wild rose, raspberry, gooseberry, saskatoon and chokecherry, all of which are used by birds and mammals. Tree species are also planted to provide ecosystem diversity and health. The planting program, in conjunction with the profusion of native plants developing from the soil amendment, provides for a diverse vegetative community on the reclamation sites. Sufficient numbers of trees are planted to meet the Alberta Environmental Protection - Lands and Forest Service (AEP-LFS) establishment criteria for a commercial stand (Alberta Environmental Protection 1994). The numbers of trees on reclamation areas should also be able to provide for a variety of wildlife and human uses.

Suncor's vision for reclamation includes the construction of stable landforms and re-establishment of productive, self-sustaining ecosystems which will provide land use capabilities equivalent to those of the pre-mining environment. The following general operational and reclamation criteria form the basis for reclamation program design:

- Structures will be geotechnically stable.
- Discharge of earth materials through surface erosion processes will be controlled to rates which are acceptable to the environment.
- Discharge of surface and seepage waters will be managed to ensure an acceptable level of impact on the Athabasca River.

- The ecosystems re-established on disturbed lands will be fully self-sustaining and will mature naturally without presenting significant risk to resident or migratory wildlife, or plant species.

- Fully reclaimed lands will be maintenance-free, thereby justifying reclamation certification.

Development of methodologies to achieve the Suncor reclamation objectives requires an understanding of the principal processes that influence ecosystem development. The types of vegetation and soil that will develop on the Suncor lease are dependent on climate, topography, parent material, drainage and time. However, of these environmental factors only parent materials and topography can be modified to any extent by Suncor. The other factors are essentially fixed by virtue of the oil sands mining and extraction methodologies or by natural conditions over which Suncor has no control.

The Suncor reclamation approach is to reconstruct a "soil" from tailings or overburden parent material and muskeg soil (peat and mineral fines). This creates a mixture that is capable of sustaining an initial erosion controlling plant cover. The reconstructed soil is also designed to be capable of supporting the growth of tree species which were found in the pre-mined forest communities and exist in areas adjacent to the lease.

F1.1.1 Soil Reconstruction

The restoration of soil capabilities to a state equal to or greater than predisturbed conditions required the definitions of reconstructed soil conditions. The design specifications ensure that the reconstructed soil provides:

- Adequate moisture supply,
- Adequate nutrient supply, and
- Acceptable erosion control.

Three natural soil types have been selected as references to represent comparable pre-mining capabilities for the three main post-mining landforms (i.e., tailings sand dykes, tailings sand plateaus, and overburden dykes/dumps). Physical and chemical parameters of these reference soils are used to assess the effectiveness of reconstructed soils in meeting the above specifications and in meeting the Suncor long term reclamation goals.

The mining operation creates a variety of land forms that must be reclaimed, including:

- Tailings sand dykes,
- Tailings sand plateaus,
- Overburden dumps and dykes,
- End pit (wall and floor),
- Tailings ponds,
- Oversize dump, and

- Ancillary areas such as coke and sulphur storage pads, ponds and roads.

Suncor utilizes a capping methodology for seedbed preparation. The capping methodology involves distribution of salvaged muskeg soil to the various reclamation areas followed by spreading to an average depth of 20 cm. Spreading is followed by application of fertilizer and a barley nurse crop which is mixed into the seedbed by harrows. This results in minimal mixing of the amendment with the spoil thereby favouring establishment of native species from seed and root fragments in the amendment material.

F1.1.2 Revegetation

The primary objectives of the Suncor revegetation program are to:

- Provide an erosion-controlling plant cover on tailings dyke slopes and overburden dump slopes, and

- Establish a permanent, self-sustaining cover of forest species.

Secondary objectives are to provide habitats which are suitable for wildlife use and which have possibilities for recreation.

Suncor has developed a revegetation program based on field trials and operational experience to aid in the achievement of these objectives. The revegetation program involves: seeding of reclamation areas with ground covers designed to control erosion; area fertilization; and establishment of appropriate woody plant species. Measures are also taken to encourage the native plant invasion onto reclaimed sites.

The distribution of the vegetation types present on the Suncor lease prior to development was related to the type of surficial materials, soils and drainage regime. The Suncor revegetation program is aimed at establishing four main vegetation types on the three main reclamation landforms (tailings sand plateaus, tailings sand slopes, and overburden dumps. The reclamation starter vegetation types are:

- Pine Forest - This vegetation type will be established on the edges of tailings sand plateaus and tailing sand slopes.

- Poplar-White Spruce/Shrub - This vegetation type will be established on the moister areas of the tailings sand plateaus.

- White Spruce-Poplar/Shrub Community - This vegetation type will be established on the overburden dumps and more mesic sites on tailings dyke slopes (lower portions of the slopes and/or areas with northerly aspects).

- Wetland Complex - This vegetation type will be established on poorly drained areas of the tailings sand plateaus.

Revegetation methodology includes fertilizer application, herbaceous ground cover establishment, woody plant establishment and revegetation area maintenance. Each of these are reviewed below.

F1.1.2.1 Fertilization

During the 1970s, fertilizer was applied and incorporated into the surface amendment, followed by annual maintenance applications for all reclaimed areas at Suncor. Composition and application rates were based on agricultural production recommendations for forage crops and annual soil monitoring results of plant available nutrients. In the mid 1980's, annual maintenance applications were reduced to minimize the potential for competition between the developing herbaceous vegetation and the planted woody seedlings.

At this time, fertilizer is applied during the initial years of an area's reclamation as an aid for the rapid development of an erosion-controlling vegetative cover. Annual fertilization is then discontinued so that the developing herbaceous cover will not compete vigorously with planted woody seedlings. The starter fertilizer formulation incorporated into the seedbed is essentially the same for tailings sand and overburden. Rates and composition are determined from initial field trials and annual monitoring. Maintenance rates are determined from criteria such as soil tests and cover performance. Typical maintenance periods, which depend on the rate of ground cover establishment, are limited to 2 to 3 years after reclamation for reclaimed overburden and 3 to 4 years for tailings sand.

F1.1.2.2 Herbaceous Ground Cover Establishment

The strategy for ground cover establishment has been to develop a vegetative cover that does not become overly competitive with outplanted woody stock, yet is still able to control erosion. Early programs prescribed agronomic species at high seeding rates which established easily and provided nearly immediate erosion control. However, these agronomic species also became restrictive to the establishment of trees and shrubs.

The current approach is to seed barley either by helicopter (primary method) or hydroseeding following seedbed preparation. Barley, an annual cereal species, provides nearly immediate erosion control in the first growing season. Additionally, it produces a litter and root biomass that further controls erosion in succeeding growing seasons. Native plants may easily invade the areas or regenerate from muskeg soil applied during seedbed preparation, while outplanted woody stock performance is also greatly enhanced. Results from a study conducted by Hardy BBT Limited (1990) for the Alberta Reclamation Research Technical Advisory Committee (RRTAC), as well as results from the annual Suncor reclamation monitoring program continues to verify the success of this approach.

F1.1.2.3 Woody Plant Establishment

Activities to establish woody plants on Suncor reclamation areas began in 1972. Since then, over 1 750 000 trees and shrubs of various species have been planted. Suncor research projects on woody plant establishment have included evaluation of: plant container types, planting time, effect of ground cover density on woody plant survival,

fertilizer amendments, species selection, direct seeding, and planting of hardwood cuttings. Assessment plots are established in reclamation operational areas for inclusion in the annual monitoring program. The results of these research efforts have been used to refine the operational afforestation program.

The selection of species and proportions of each species in the planting mix is based on existing field conditions and the vegetative type expected to develop on the site. The species selected are representative of different stages of vegetative succession in the region. This means that as the woody cover develops and the micro-environment modifies to provide favourable conditions for later successional and climax species, these species will be present and able to take advantage of the change in conditions. In this manner, the process of natural succession is accelerated towards the conceptual vegetation covers.

Tree and shrub seedlings are planted at an average total density of 2500 stems/ha. This planting density was selected so that sufficient numbers are planted to ensure adequate stocking of each species after initial mortality and to permit the establishment of volunteer plants. The species composition numbers are subject to change depending on the availability of planting stock and specific reclamation site conditions.

The planting program is designed to provide a diverse mixture of woody stemmed species on the reclaimed areas. The species mixture includes wild rose, raspberry, gooseberry, saskatoon, and chokecherry, all of which are used by birds and mammals. Tree species are also planted to provide ecosystem diversity and health. The planting program in conjunction with the profusion of native plants developing from the soil amendment provides for a diverse vegetative community on the reclamation sites.

Seedlings are propagated from seed and cuttings collected from the Fort McMurray area. Outplanting periods are early spring and late summer depending on logistics and availability of reclaimed areas. Planting is undertaken as soon as possible after soil reconstruction has been completed.

F1.2 RECLAMATION RESEARCH AND MONITORING

Suncor conducts annual monitoring programs in reclaimed areas specifically to assess herbaceous vegetation growth as well as soil physical and chemical properties. Results of these monitoring programs have been documented and are reported to Alberta Environmental Protection in the annual Development and Reclamation report.

Annual assessments of tree and shrub survival and growth have been conducted in areas where a known number of seedlings have been outplanted. In addition, several other studies related to land reclamation, as well as groundwater monitoring and fine tailings handling, have been undertaken. Suncor will continue research in these areas to ensure that reclamation goals are achieved.

F1.2.1 Vegetation and Soil Monitoring of Reclaimed Land

Vegetation and soil characteristics in reclaimed areas on the Suncor Lease are routinely monitored for Suncor by both in-house staff and external personnel. The monitoring program consists of regular annual vegetation cover assessment and soil sampling from areas reclaimed within the past three to four years. Additionally, a detailed assessment and sampling of older reclaimed areas is completed every fifth year. This information provides input into the Graphical Information System (GIS) (Arc Info & Arc View) which is used by Suncor as a planning tool, to relate the monitoring data to the soils and plant development on the reclamation areas.

F1.2.1.1 Weather Data

The development of a vegetative cover can be affected by meteorological conditions. Therefore, the amount of precipitation, temperature and the seasonal variations of these factors is very important when assessing area development. The annual reclamation monitoring program has shown that normal precipitation and temperature together with a relatively even distribution of precipitation during the growing season results in superior vegetation growth in all reclaimed areas.

F1.2.1.2 Soil Sampling

Soil samples are collected as part of the reclamation program, in conjunction with the vegetation assessment. On reclaimed tailings sand, three layers were sampled per transect at most sites including the amended layer (approximately 0 to 15 cm), the layer immediately below the amended layer (15 to 30 cm) and the 45 to 60 cm layer. Samples were taken from three locations (i.e., approximately the end points and the middle of each transect). These were bulked to form one composite sample per layer per transect. In most cases, portions of several samples were bulked again to form one composite sample representing a specific reclamation area which in turn are submitted for laboratory analysis. Since soil properties of the lower layers (analyzed the year the site was reclaimed) tend to change much more slowly than at the surface, it was considered unwarranted to repeat the analysis of the lower layers within such a short time period.

F1.2.1.3 Vegetation Assessment

Herbaceous Species

Vegetation cover and height data are collected from assessment plots located on transect line(s) running through the reclamation area. These transects are determined through review of aerial photographs of the areas. At each location, a permanent 30 m transect is positioned at mid-slope, parallel to the contour. Ten 0.10 m^2 quadrats are systematically placed along the transect and the average vegetation height (of herbaceous species only), percent living plant cover (by individual species) and dead plant cover are estimated within each quadrat.

Tree (Woody Stemmed Vegetation) Assessments

Suncor uses two methods for assessing woody stemmed vegetation establishment, growth and performance. The Primary Assessment method is used to assess reclaimed areas three to four years after tree planting has been completed on a reclamation site. The Regeneration Survey method is conducted on all areas that have been revegetated for a period of 8 years or greater.

Primary Assessment:
The Primary Assessment procedure is employed to monitor the success of establishing woody stemmed vegetation on a reclamation site over the short term. Collected data is used to plan maintenance treatments for individual sites (e.g., fill-in planting and fertilization).

The results from the survey method, while variable, provide an indication about the need for additional work on a reclamation area. Areas expected to develop into a commercial forest stand are to have 1200 stems/ha at the end of the assessment period. A survey may indicate that insufficient woody stemmed plants have become established to meet the Alberta Environmental Protection - Land and Forest Services (AEP-LFS) Regeneration Standard. Should this occur, fill-in planting is implemented or other mitigative work is completed. Tailings sand slopes that were reclaimed primarily for erosion control are also assessed. If these areas do not meet the forest stand criteria, they may be replanted or left as open wildlife habitat.

The main detrements to tree establishment on reclamation sites are a southerly aspect and the presence of a grass mat. Excessive grass growth, in conjunction with the southern exposure aspect, result in severe drying conditions which stress trees or cause tree mortality. This may result in the requirement to undertake additional tree planting work.

Regeneration Survey:
The second method of assessing the vegetation involves utilization of the Regeneration Survey procedure developed by the AEP-LFS. The assessment survey must be conducted by a certified person using the AEP-LFS Regeneration Survey Manual (Alberta Environmental Protection 1994).

The AEP-LFS mixedwood establishment survey is utilized on the Suncor site to help evaluate tree survival and native invasion on reclamation areas. According to the survey criteria, acceptable trees, eight years following planting, include 50+ cm spruce, or 100+ cm jack pine, larch, aspen, balsam poplar, or birch. These species, once they have reached a commercial size, all have potential for use in lumber or pulp industries. The AEP-LFS establishment survey was modified slightly to include the presence of other woody stemmed plants because Suncor's reclamation focus is to develop a diverse ecosystem on the reclamation sites.

F1.3 HISTORY OF LAND RECLAMATION TECHNIQUES AT SYNCRUDE

Reclamation of lands disturbed by Syncrude has been taking place since 1976; initially on construction disturbances and then subsequently on mine/plant wastes, both in-pit and out-of-pit. Syncrude's reclamation program has been continually modified in response to regulatory changes and to information derived from monitoring. Some of the strategies have met with substantial success, in terms of forest ecosystem initiation, while others have not. Reclamation techniques that have been employed by Syncrude can be summarized as follows:

Reclamation Technique	Surface Amendment for Overburden	Surface Amendment for Tailings Sand	Revegetation Species
A	None	15 cm peat	Agronomic grass/legume seed mix
B	10 to 20 cm peat	15 cm peat over 10 cm clay	Agronomic grass/legume; wide variety of trees & shrubs
C	1 m Holocene/Pleistocene material on (assumed) saline/sodic overburden	15 cm peat over 10 cm clay	Low rates of grass/legume; wide variety of trees & shrubs
D	1 m suitable surface material on (assumed) saline/sodic overburden	50 cm $\pm$ 20 cm suitable surface material	Emphasis on trees - few species, no seeding except on steep slopes.
E	50 cm suitable surface material on non-saline / non-sodic overburden (construction specs)	70 cm $\pm$ 10 cm suitable surface material	Oats/barley nurse crop; emphasis on trees - few species (monoculture plots)
F	50 cm suitable surface material on non-saline / non-sodic overburden (construction specs)	35 to 50 cm suitable surface material to create class 2/3 soil capability for forestry	Barley nurse crop; emphasis on trees - 1 conifer + 1 deciduous (poplar or dogwood)

F1.3.1 Surface Preparation

Syncrude's objective in soil reconstruction is to produce a self-sustaining soil cap over the overburden and tailings sand materials that meets or exceeds the predisturbance soil capability levels. The soils used include both the surface organic soils and the underlying mineral horizons that meet the "Suitable Soil" criteria. The suitable soils are delineated by soils surveys and auger drilling programs. The mineral soils often have some chemical and physical limitations such as high pH (7-8) and high clay contents. The underlying bedrock units of the Clearwater and McMurray Formations have high salinity and sodicity and are not used as reclamation materials. However, they make up the largest volumes in the

overburden dumps and in-pit structures and require a thicker soil cap to prevent salt exsolution.

The creation of more upland sites in the post mining area has enabled Syncrude to create a more productive site for forest development – one of the main vegetation objectives in the final landscape. The reclamation soils are used to cap the following upland mining structure:

- Tailing Dykes
- External Sand Storage Dumps
- External Overburden Dumps
- In-pit Containment Structures

During the initial years (1978 to 1983) of reclamation at Syncrude, tailings sand slopes were reclaimed by capping with a nominal 10 cm layer of clayey overburden followed by a 15 cm layer of peat and incorporating these amendments into the sand using a cultivator and discs or a rotovator.

The second reclamation approach evaluated at Syncrude began in 1986 when the amendment material was applied as a single 50 cm cap. Amendment material used for reclamation was rated as having either Fair or Good reclamation suitability based on criteria set out by the Soil Quality Criteria Working Group (1987). After placement, the amendment was prepared using a rome disc bedder which left prominent ridges (30 to 50 cm high parallel to the contour on slopes).

Subsequent reclamation of tailings sand increased the depth of the amendment material to 70 cm and efforts were made to increase the surface organic matter content. For example, if the reclamation material placed on the site had less than 20% organic (peat) by volume, a nominal 15 cm top dressing of higher organic peat (50 to 100% by volume) material was placed at the surface. The thickness of the lower material was reduced to 55 cm such that the total amendment thickness was maintained at 70 cm. The current reclamation approach is based on the Land Capability Classification for Forest Ecosystems in the Oil Sands Region (Leskiw 1998). In general, according to this classification, a 35 to 50 cm cap of suitable surface soil can effectively provide a class 2 or 3 capability for foestry in the landscape.

In the initial years (1978-79) of overburden reclamation at Syncrude, no surface amendment was applied. However, due to poor revegetation success, these areas have subsequently (in 1990) been capped with a 100 cm cap of material rated as Fair or Good reclamation suitability. Areas of overburden reclaimed in 1982 and 1983 were capped with a 10 to 20 cm layer of peat. In 1984, overburden reclamation methodology was altered to include a 100 cm cap of Fair or Good reclamation suitability material placed over overburden materials that were assumed to be saline or sodic, followed by discing or plowing to incorporate fertilizer and break up lumps. In more recent years, where the

overburben has been demonstrated to be non-saline and non-sodic, the thicknes of the cap material has been reduced to 50 cm.

F1.3.2 Application of Fertilizer

In the early years of reclamation, fertilizer was applied after initial placement of reclamation material and followed by annual maintenance applications up until 1982. Since then, fertilizer has only been applied the first year except in rare situations where deficiency symptoms are evident and then only if there is not a competing grass sward. It has always been the practice to till the starter fertilizer into the surface amendment material by discing in order to incorporate the phosphate and organics and to smooth the surface.

F1.3.3 Revegetation

The main objectives of vegetation establishment at Syncrude are:

- To create a natural self-sustaining ecosystem,
- To stabilize slopes and prevent erosion, and
- To meet end land use objectives as agreed upon by the stakeholders.

Revegetation techniques at Syncrude closely parallel those described above for Suncor. In the early years, agronomic grasses and legumes were applied at high rates, a practice that was discontinued for all areas in 1985 in an effort to promote revegetation of woody species. From 1986 to 1989 reclaimed areas were not seeded. This resulted in a significant amount of erosion in some sloped areas. Consequently, beginning in 1990, reclaimed slopes of tailings sand or overburden have been seeded with an annual barley or oats crop whereas relatively level areas have not been seeded. Exceptions to this approach are the large areas of relatively level overburden and tailings sand that have been revegetated with species that provide forage for bison.

Revegetation techniques for woody species is also very similar to the approach described above for Suncor, although Syncrude places more emphasis on trees than shrubs in their planting program. Dominant species are jack pine, white spruce, aspen and red-osier dogwood.

F1.3.4 Monitoring

Syncrude's reclamation monitoring program has been continually modified in response to regulatory changes and to information derived from monitoring. The program will continue to change as more information becomes available and corporate regulatory philosophies mature. A 20 m x 20 m tree assessment plot is established in each reclaimed area designated for forestry to monitor tree growth and survival. Tree measurements are taken in the first year and then at five year intervals. The assessment plots are also used to monitor native species establishment and biodiversity. A soil monitoring program has also been established to measure soil thickness and chemical and physical parameters of the

reclaimed soils. This also provides the opportunity to classify the soil based on the Land Capability Classification of Forest Ecosytems in The Oil Sands Region (Leskiew 1998).

F2. REVEGETATION SUCCESS

F2.1 RECLAIMED TAILINGS SAND

A detailed study of vegetation on reclaimed tailings sand structures was undertaken in 1995 at both Suncor and Syncrude. For comparison, study plots (measuring 10 x 10 m) were also sampled in adjacent natural stands of the four dominant upland vegetation community types in the vicinity. A summary of the plots sampled is shown in Table F.1. Table F.2 shows the average number of species and percentage cover of four main vegetation groups, while the percentage cover of all species encountered is provided in Tables F.3 and F.4.

By far the greatest number of sites assessed in reclaimed areas (47 at Suncor, 23 at Syncrude) were relatively old (14 to 24 years) where the peat amendment was incorporated into the sand and an agronomic grass/legume mix was applied Table F.1. Only 12 sites were assessed where the current reclamation approach was implemented whereby the amendment is applied as a cap and only an annual barley is seeded the first year. These sites range from 4 to 10 years old and are referred to as "No Seed" in Table F.1. Only 2 sites occured on level terrain (Dyke 2 Plateau). Thickness of the surface amended soil layer ranged from an average 16 to 33 cm except for the non-seeded sites on the Mildred Lake Settling Basin (MLSB) at 53 cm. Thickness of the surface litter layer (undecomposed plant material) averaged 1 cm or less at all sites. Rooting depth (of the herbaceous vegetation) averaged 32 to 53 cm, with no obvious relationship with site age or treatment. It should be noted that there is a considerable amount of subjectiveness in this measurement.

Characteristics of the natural forest stands differed from the reclaimed sites in several ways. Most importantly, all of the natural sites were on level terrain. Thickness of the organic soil layer averaged 14 to 22 cm for the mixedwood sites, comparable to reclaimed areas, but only 2 to 4 cm at the jack pine and aspen forest communities. Litter layer thickness ranging from 2 to 8 cm was considerably greater than reclaimed sites, but rooting depth of the herbaceous species was comparable averaging 42 to 50 cm.

The relatively high numbers of grasses and legumes on reclaimed sites was the most obvious difference compared to the natural stands. Not surprisingly, this difference was most apparent when comparing the reclaimed sites that were seeded, where grasses and legumes comprised the greatest number of species. In contrast, other herbaceous species were the most abundant group among the natural communities. The average percentage cover per plot (Table F.2) clearly illustrates the dominance of grasses and legumes in seeded reclaimed areas whereas trees provided most of the cover in natural stands. Grass and legume cover ranged from 50 to 100 percent on seeded sites but was virtually absent in natural forest stands. Trees provided less than 10 percent cover at seeded sites and between 20 and 30 percent cover at older non-seeded sites (Dyke 2 Plateau and MLSB), compared with 55 to 90 percent cover in the natural forest communities.

The percentage cover of other herbaceous species was comparable between the non-seeded and natural stands, but the actual species providing the cover were different. Fireweed, sow thistle and sedge provided almost all of this cover on the reclaimed sites but were virtually absent in the natural stands (Table F.4).

The similarity between the reclaimed sites and each of the natural forest communities was assessed by calculating the "coefficient of community" for each reclaimed site and natural forest site. This coefficient provides a numerical comparison of the number of species common to both sites. The value of the coefficient for each of the reclaimed site groups compared with each of the natural forest communities is given in Table F.5. In general, the results indicate there was little similarity in terms of species composition between any of the reclaimed areas with the natural stands. The oldest reclaimed sites on Suncor's Tar Island Dyke (TID) and Syncrude's MLSB seeded to grasses and legumes typically had values of 0.10 or less. Sites seeded to native grasses (Dyke 2) and sites not seeded (TID and MLSB) had slightly higher values, typically between 0.1 and 0.2 or more. In most cases, the species that were common between the sites were the trees and shrubs planted as part of the reclamation program.

F2.2 RECLAIMED OVERBURDEN

A study using consistent methodology has not been conducted to compare vegetation establishment on reclaimed overburden at the two minesites and in nearby natural forest stands. However, both Suncor and Syncrude have conducted long-term monitoring of vegetation in these areas. Table F.6 presents data on the average number of species and percentage cover from a variety of sites monitored on reclaimed overburden. The data has been separated into the same four vegetation groups as presented above for the reclaimed tailings sand sites.

All of the sites monitored and presented in Table F.6 occur on overburden slopes with an average 35% slope angle. The sites monitored at Suncor were typically reclaimd by placing a 15 to 20 cm cap while those at Syncrude were capped with up to 100 cm of amendment material.

The data show a similar trend to reclaimed tailings sand with respect to the influence of seeding on long-term vegetation cover. At both Suncor and Syncrude, sites that were seeded were dominated by grasses and legumes in terms of percentage cover. This is most evident for the Suncor sites where trees, shrubs and other herbaceous species were almost non-existent at the seeded sites even after 15 to 17 years. In contrast, all four groups were well represented at the sites not seeded. The difference at the Syncrude sites was less apparent. However, it is important to note that the methodology for vegetation cover monitoring is different at Syncrude and therefore the data should not be compared directly with the Suncor data. Trees are not included in the Syncrude survey and much more area is assessed per site compared to Suncor.

F2.3 SUMMARY OF VEGETATION ESTABLISHMENT IN RECLAIMED AREAS

The grass and legume mixtures that were seeded in the early years of reclamation at both Suncor and Syncrude were highly effective in establishing an erosion resistant vegetation cover on reclaimed overburden and tailings sand. These vegetation communities have persisted for over 20 years and have resisted the establishment of native species either through natural invasion or planting programs. The dominant species at these reclaimed sites are typically the seeded agronomics: awnless bromegrass, creeping red fescue, and alfalfa. Natural invasion is occurring very slowly. It is important to note however, that there are areas up to 0.5 ha in size where dense stands of trees and shrubs have been successfully established at both minesites in these formerly seeded areas.

Sites that were not seeded or only seeded to an annual barley have typically become dominated by a variety of herbaceous species that provide close to 100% total areal cover within a few years after reclamation. Dominant species include perennial sow thistle, fireweed, sweet clover and hawksbeard. The seeded barley provides effective erosion control during the first year and in most instances, the invading species maintain this control in the following years. Trembling aspen, balsam poplar and a variety of willows and other native shrubs frequently invade these areas within a few years of reclamation.

Table F.1

Vegetation Plots Sampled on Reclaimed Tailings Sand in 1995 at Suncor, Syncrude, and Nearby Natural Forest Stands.

	Suncor					Syncrude		Natural Forest Stands			
	TID Seeded (old)	TID Seeded (base)	Dyke 2 Seeded	Dyke 2 Plateau No Seed	TID No Seed	MLSB Seeded	MLSB 2.3.1.2.1.1 o Seed	Mixed-wood	Spruce Dominated Mixedwood	Jack Pine	Aspen
Number of Plots	47	6	8	2	3	23	7	2	2	2	2
Age* (years)	20-24	13-15	7-12	10	4	14-15	8-9	144	198	51	98
Topographical Position	40% slope	40% slope	40% slope	Level	40% slope	27% slope	27% slope	level	level	level	level
Organic Soil Thickness (cm)	19	16	23	26	33	31	53	14	22	2	4
Litter Thickness (cm)	1	< 1	1	1	< 1	1	1	8	4	2	4
Rooting Depth (cm)	53	49	35	32	34	45	40	46	43	50	42

* Age of Syncrude and Suncor plots is based on the year the site was reclaimed.
Age of Natural Forest Stands is based on the oldest tree cored in the stand.

Note: TID, Dyke 2, Dyke 2 Plateau and MLSB are tailings sand structures at Suncor and Syncrude.

Table F.2
Average Number of Species and Percentage Cover in Plots Sampled on Reclaimed Tailings Sand in 1995 at Suncor, Syncrude, and Nearby Natural Forest Stands

	Suncor					Syncrude		Natural Forest Stands			
	TID Seeded (old)	TID Seeded (base)	Dyke 2 Seeded	Dyke 2 Plateau No Seed	TID No Seed	MLSB Seeded	MLSB No Seed	Mixed-wood	Spruce Dominated Mixedwood	Jack Pine	Aspen
Average No. Species:											
Trees	1.9	0.7	2.4	2.3	2.0	0.8	2.4	3.5	4.0	2.5	2.5
Shrubs	0.8	1.2	2.1	1.3	2.5	1.5	1.9	3.5	5.5	1.0	4.5
Grasses/Legumes	4.2	4.5	4.9	2.7	2.0	4.0	3.4	0.0	0.0	1.0	0.5
Other Herbaceous	3.3	2.0	1.6	6.3	4.5	2.7	3.1	5.5	9.5	2.5	7.0
Average Cover (%):											
Trees	11.9	2.2	4.6	5.2	23.5	10.3	26.6	63.0	90.0	63.0	55.3
Shrubs	6.7	1.6	3.1	2.2	49.5	15.6	10.0	33.8	38.5	15.0	34.0
Grasses/Legumes	52.6	99.6	85.4	2.7	8.5	85.4	39.1	0.0	0.0	3.0	1.0
Other Herbaceous	10.6	8.9	1.7	107.8	43.8	14.0	13.7	43.5	45.3	33.5	42.3

Table F.3
Average Percentage Cover of Tree and Shrub Species in Plots Sampled on Reclaimed Tailings Sand in 1995 at Suncor, Syncrude, and Nearby Natural Forest Stands

	Suncor					Syncrude		Natural Forest Stands			
	TID Seeded (old)	TID Seeded (base)	Dyke 2 Seeded	Dyke 2 Plateau No Seed	TID No Seed	MLSB Seeded	MLSB No Seed	Mixed-wood	Spruce Dominated Mixedwood	Jack Pine	Aspen
Trees											
Alder sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	25.0	7.5
Aspen	4.0	0.0	0.0	0.0	1.3	0.6	15.7	12.5	12.5	0.5	40.0
Balsam Fir	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	5.0	0.0	0.0
Balsam Poplar	1.1	0.2	1.8	22.5	0.2	0.1	0.9	7.5	1.5	0.0	0.3
Green Ash	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jack Pine	1.3	0.0	1.9	0.0	0.0	7.5	4.3	0.0	0.0	37.5	0.0
Lodgepole Pine	3.0	0.2	0.3	0.5	3.7	0.0	0.0	0.0	0.0	0.0	0.0
Manitoba Maple	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Siberian Elm	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tamarack	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
White Birch	0.1	1.7	0.0	0.0	0.0	0.0	0.0	12.5	1.0	0.0	0.0
White Spruce	1.2	0.2	0.6	0.5	0.0	1.6	5.7	30.0	67.5	0.0	7.5
Shrubs											
Blueberry sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	15.0	7.5
Canada Buffaloberry	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	1.5	0.0	1.5
Chokecherry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Common Caragana	3.6	0.0	0.0	0.0	0.0	11.2	0.0	0.0	0.0	0.0	0.0
Gooseberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
Labrador Tea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0
Low Bush Cranberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5	5.0	0.0	0.0
Raspberry sp.	0.0	0.0	0.0	0.0	1.0	1.1	0.0	0.0	0.3	0.0	0.0
Red-osier Dogwood	0.3	1.1	0.1	1.0	0.0	2.6	6.6	20.0	17.5	0.0	0.0
Rose sp.	0.0	0.0	1.8	0.5	0.2	0.0	0.1	10.3	4.0	0.0	2.5
Saskatoon	0.0	0.3	0.8	0.0	0.0	0.4	0.0	0.0	0.3	0.0	1.5
Shrubby Cinquefoil	0.0	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Silverberry	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Snowberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	5.0	0.0	0.0
Willow sp.	2.6	0.0	0.4	47.5	1.0	0.1	3.3	0.0	2.5	0.0	1.0

Table F.4
Average Percentage Cover of Herbaceous and Nonvascular Species in Plots Sampled on Reclaimed Tailings Sand in 1995 at Suncor, Syncrude, and Nearby Natural Forest Stands

	Suncor					Syncrude		Natural Forest Stands			
	TID Seeded (Old)	TID Seeded (Base)	Dyke 2 Seeded	Dyke 2 Plateau No Seed	TID No Seed	MLSB Seeded	MLSB No Seed	Mixed-Wood	Spruce Dominated Mixedwood	Jack Pine	Aspen
Grasses/Legumes											
Alfalfa	12.7	6.7	9.3	0.0	0.0	16.6	13.6	0.0	0.0	0.0	0.0
Alsike Clover	0.2	0.1	3.9	0.0	0.0	1.2	1.4	0.0	0.0	0.0	0.0
Awnless Brome	23.4	40.2	1.9	0.0	0.2	22.5	3.1	0.0	0.0	0.0	0.0
Bent Grass sp.	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0
Birdsfoot Trefoil	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cicer Milk Vetch	0.0	33.3	0.0	0.3	0.0	1.7	0.1	0.0	0.0	0.0	0.0
Crested Wheatgrass	1.3	1.7	0.0	0.0	0.0	7.2	0.0	0.0	0.0	0.0	0.0
Foxtail Barley	0.0	0.0	0.1	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.0
Hair Grass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kentucky Bluegrass	2.2	0.0	1.5	7.5	0.3	0.2	2.9	0.0	0.0	3.0	0.5
Red Clover	0.0	0.0	0.0	0.0	0.0	00	0.0	0.0	0.0	0.0	0.0
Red Fescue	11.9	16.5	65.3	0.5	0.0	33.5	5.7	0.0	0.0	0.0	0.0
Sweet Clover sp.	0.1	0.0	0.1	0.0	1.0	1.2	11.4	0.0	0.0	0.0	0.0
Timothy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wheatgrass sp.	1.2	0.5	3.3	0.0	0.8	1.4	0.7	0.0	0.0	0.0	0.0
White Clover	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table F.4 (cont'd)

	Suncor					Syncrude		Natural Forest Stands			
	TID Seeded (Old)	TID Seeded (Base)	Dyke 2 Seeded	Dyke 2 Plateau No Seed	TID No Seed	MLSB Seeded	MLSB No Seed	Mixed-Wood	Spruce Dominated Mixedwood	Jack Pine	Aspen
Other Herbaceous											
Aster sp.	0.1	0.0	0.0	0.0	0.2	0.1	0.1	1.0	1.0	0.0	0.3
Bearberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	15.0
Bishop's Cap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	4.0	0.0	0.0
Bluebell	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bog Cranberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	5.0
Bunchberry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	10.0	0.0	5.0
Canada Thistle	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chickweed sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Club Moss sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	10.0
Coltsfoot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	2.5
Columbine sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
Common Dandelion	5.2	0.0	0.0	0.0	1.3	0.3	2.1	0.0	0.0	0.0	0.0
Fireweed	2.8	2.5	0.3	2.0	40.0	1.0	2.6	0.0	0.0	0.0	0.3
Geranium sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Goldenrod sp.	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Grape Fern	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hawkweed sp.	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hawk's Beard sp.	0.2	0.1	0.0	0.0	4.7	0.0	0.9	0.0	0.0	0.0	0.0
Horsetail sp.	0.0	0.0	0.0	0.0	0.7	0.0	0.0	12.5	14.0	0.0	0.0
Lamb's Quarter	0.0	0.0	0.3	0.0	1.7	0.0	0.1	0.0	0.0	0.0	0.0
Mustard sp.	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Northern Bedstraw	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5	4.5	0.0	0.0
Northern Twinflower	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	3.5	0.0	10.0
Pea Vine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Pepper Grass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table F.4 (cont'd)

	Suncor					Syncrude		Natural Forest Stands			
	TID Seeded (Old)	TID Seeded (Base)	Dyke 2 Seeded	Dyke 2 Plateau No Seed	TID No Seed	MLSB Seeded	MLSB No Seed	Mixed-Wood	Spruce Dominated Mixedwood	Jack Pine	Aspen
Other Herbaceous											
Perennial Sow Thistle	1.6	5.3	0.9	0.3	58.3	8.8	6.6	0.0	0.0	0.0	0.0
Cinquefoil sp.	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rush sp.	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sedge sp.	0.0	0.5	0.0	40.5	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Stinging Nettle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strawberry sp.	0.0	0.0	0.0	0.3	0.0	0.1	0.0	0.5	2.5	0.0	0.0
Tall Lungwort	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	2.8	0.0	0.0
Tartary Buckwheat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified sp.	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.3
Violet sp.	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.5	0.0	0.0	0.0
Wintergreen sp.	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.5	2.5
Yarrow sp.	0.2	0.2	0.1	0.3	0.0	1.3	1.0	0.0	0.0	0.0	0.0
Moss and Lichen											
Moss sp.	2.69	10.3	14.6	2.8	10.7	4.1	16.7	17.5	25.0	10.0	2.5
Lichen sp.	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Ground	2.4	4.1	0.9	0.0	15.0	4.3	33.9	0.0	0.0	0.5	0.0

Table F.5

Average Coefficient of Community* for Reclaimed Tailings Sand Sites Compared with Natural Forest Stands

Natural Forest Type	Site	Reclaimed Sites						
		Suncor					Syncrude	
		TID Seeded (old)	TID Seeded (base)	Dyke 2 Seeded	TID No Seed	Dyke 2 Plateau No Seed	MLSB Seeded	MLSB No Seed
Mixedwood	2	0.10	0.10	0.24	0.08	0.29	0.05	0.21
	X	0.06	0.03	0.11	0.12	0.08	0.04	0.14
Spruce Dominated Mixedwood	13	0.10	0.08	0.19	0.16	0.19	0.08	0.21
	16	0.10	0.05	0.16	0.18	0.22	0.07	0.26
Jack Pine	18	0.11	0.00	0.13	0.17	0.06	0.07	0.22
	19	0.10	0.00	0.13	0.07	0.06	0.05	0.11
Aspen	14	0.12	0.04	0.21	0.21	0.22	0.07	0.22
	22	0.11	0.07	0.19	0.19	0.15	0.07	0.17
Number of Sites Averaged		47	6	8	3	2	23	7

* Coefficient of Community = $2C \div (S_1 + S_2)$ where C = Number of common species; S_1 = Number of species in the Natural Forest Site; and S_2 = Number of species in the Reclaimed Site.

Table F.6
Average Number of Species and Percentage Cover in Plots Sampled on Reclaimed Overburden at Suncor and Syncrude

	Suncor			Syncrude	
	Waste Area 5, Waste Area 16 Seeded	**Waste Area 16 No Seed**	**Waste Area 8, Waste Area 19 No Seed**	**Waste Area S-4 Seeded**	**Waste Area S-4 No Seed**
Number of Sites	5	8	16	7	2
Age (Years)	15 - 17	10 - 15	6 - 9	10	10, 11
Average No. Species:					
Trees	0.0	1.0	2.8	N/A*	N/A
Shrubs	0.0	0.9	7.6	1.1	0.0
Grasses/Legumes	3.6	2.1	2.1	3.3	3.0
Other Herbaceous	0.6	2.5	3.6	5.6	9.5
Average Cover (%):					
Trees	0.0	23.7	27.1	N/A	N/A
Shrubs	0.0	6.9	14.5	7.6	0.0
Grasses/Legumes	90.9	32.8	30.4	43.3	32.5
Other Herbaceous	1.9	13.4	34.0	32.0	45.0

*N/A = Not Applicable (Trees are not included in the vegetation cover monitoring assessment conducted by Syncrude)

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APPENDIX G

SEED ZONES AND SOURCES

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SEED ZONES AND SOURCES

Prepared by: Bert Ciesielski, Alberta Environmental Protection

G1. SEED ZONES AND SOURCES

Current provincial seed provenance rules require seed or propagule material used on Crown lands to be native to the Natural Subregion and be obtained from within 50 miles (80 km) and within 500 feet (150 m) elevation from the planting site. All tree seed collected for use on Crown land must be registered with the Land and Forest Service, Tree Improvement Center. All trees planted on Crown land must come from registered seed sources.

The Forest Management Division is currently reviewing the provincial seed provenance rules to more definitively show the locations of zones where suitable seed can be obtained. Publication is expected in the fall of 1998. The issue of movement across zone boundaries is still to be discussed and will vary depending on the type of boundary. Where genetic and ecological gradients are steep or abrupt, or zones are bounded by natural subregion boundaries, movement across zone boundaries will differ from those within relatively homogenous Natural Subregions. The initial discussion has been to use allowable movement within a township (6 miles, 9.6 km) across seed zone boundaries within Boreal Natural Subregions. Natural Regions and Subregions of Alberta are summarized in Alberta Environmental Protection (1994).

The current draft seed zone map for the Athabasca Oil Sands Region is shown in Figure G.1. The new seed zones were developed for trees but are also intended to cover shrubs and provide a framework for herbaceous vegetation as well. Descriptions of the new seed zones in the Athabasca oil sands region follows.

G2. DRAFT SEED ZONE DESCRIPTIONS

G2.1 DRAFT SEED ZONE 8A

G2.1.1 Geography

This seed zone is situated in northeastern Alberta and consists of an area east of Fort McMurray. The zone extends from 58 05' N to 55 49' N latitude, and from 110 00' W to 111 49' W longitude. Elevations range from 300 to 660 metres and the total area is approximately 17,040 km^2.

Figure G.1 Draft Provincial Seed Zone Map for the Athabasca Oil Sands Region

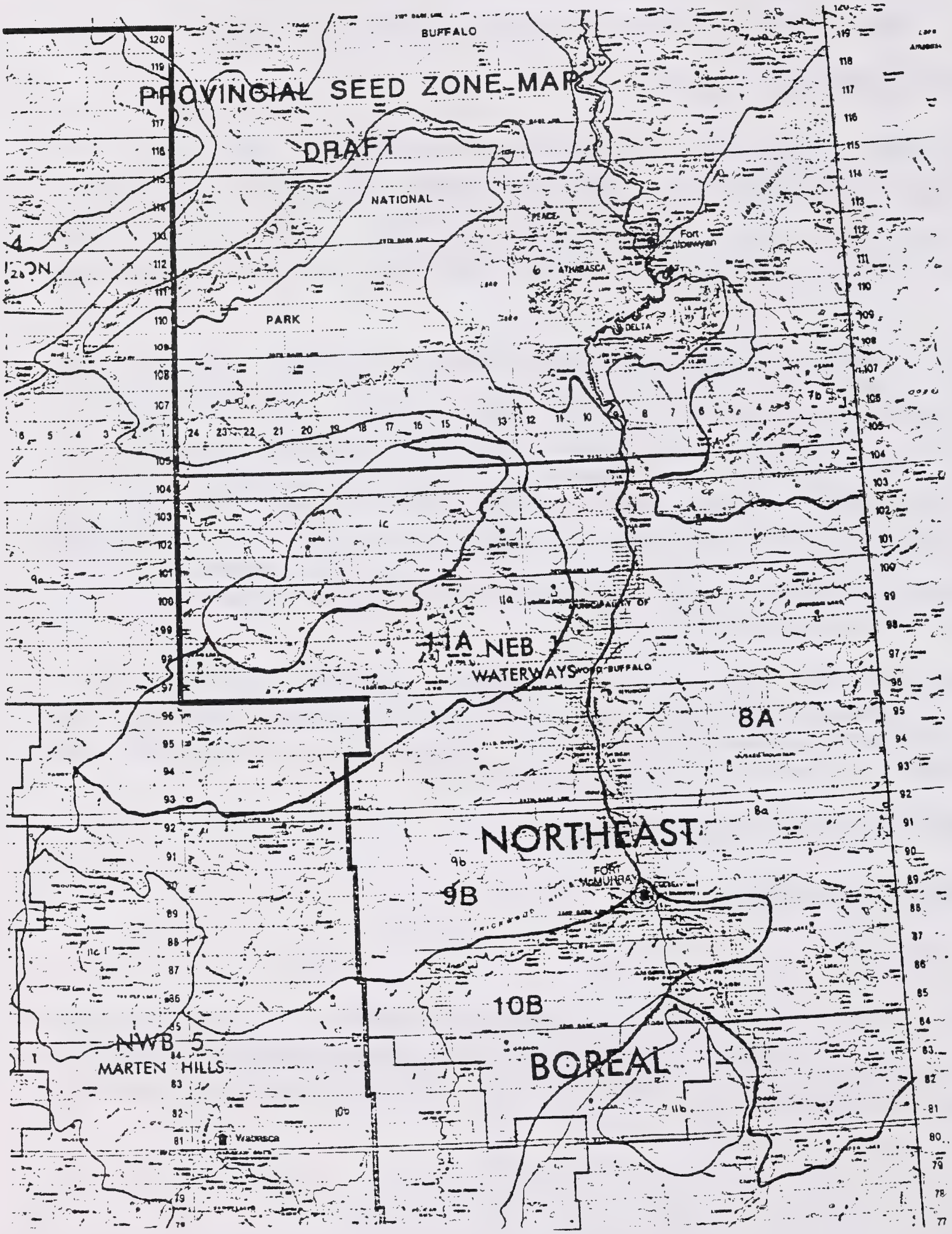

Table G.1
Summary of Climatic Data for Draft Seed Zone 8A Stations

Climate Station And Elevation	Mean June-August Temp (°C)	Mean Summer Precip J-J-A (mm)	Mean Annual Temp (°C)	Mean Annual Precip (mm)	Frost Free Period (Days)	Growing Degree Days >10°C (Days)	Day Length (Longest) (Hours)
Anzac (495 m)	14.6	224.5	0.0	503.5	93	527.6	18
Bitumont LO (349 m)	14.9	217.7	-	-	-	-	18
Cowpar LO (563 m)	14.6	250.2	-	-	105	-	18
Fort McMurray (369 m)	15.1	216.1	-0.2	471.9	84	575.8	18
Gordon Lakes LO (488 m)	14.6	233.6	-	-	96	-	18
Johnson Lakes LO (549 m)	14.1	227.5	-	-	93	-	18
Mildred Lake (310 m)	-	-	-	-	88	-	18
Muskeg Mountain LO (652 m)	14.0	234.0	-	-	101	-	18
Tar Island (288 m)	15.9	178.4	-0.1	408.5	109	686.5	18
Mean	14.8	221.1	-0.1	461.3	95.4	596.6	18

G2.1.2 Topography and Soils

The topography for most of the zone is generally level with areas of gently rolling to rolling terrain. Parent materials are commonly a mixture of sandy alluvial glacial till and gravelly outwash. Eutric Brunisols and Podzols are common on these coarse-textured upland sites and occupy approximately 40% of the zones land area. Gray Luvisolic soils occur occasionally on finer textured upland till sites. Organic and Gleysolic soils represent approximately 60% of the land area and are located in low lying areas. Peat depths of up several feet have been measured, and permafrost has been encountered.

G2.1.3 Climate

There are several climatic stations for this area (Table G.1) with three stations recording annual data. The remaining seasonal stations have a mean June-August temperature of 14.8°C and average total precipitation for the same period of 221.1 mm. The mean annual temperature is -0.1°C with an annual total precipitation of 461.3 mm. Growing season temperatures appear typical for core areas of the Central Mixedwood Subregion but with growing season amounts appear to be higher.

G2.1.4 Ecology

Pure jack pine forest types on coarse textured mineral soils make up a large portion of the vegetation in this zone. Understories are predominantly composed of lichens with lesser amounts of bearberry, low bilberry, bog cranberry and prickly rose. Mixed jack pine and black spruce types in upland to bog transition areas are also common. Mixed black spruce and tamarack forest types which occupy extensive areas of bog have a ground cover of Labrador tea and peat mosses or when richer fens are present, dwarf birch, sedges and brown mosses. Areas north of the Clearwater River and east of the Athabasca River are dominated by these types.

Early successional trembling aspen and balsam poplar forest types which occur on finer textured upland sites in the southern portion of the seed zone and along the Athabasca River typically have understory species including low bush cranberry, beaked hazelnut, prickly rose, red osier dogwood, march reed grass, sarsaparilla, dewberry, cream-coloured peavine, pink wintergreen and twin flower. Later successional white spruce forest types which are generally restricted to areas along the Clearwater and Athabasca River valleys, have a greater proportion of feather mosses in the understory. Small amounts of paper birch occur throughout the zone and occasionally forms pure stands.

G2.1.5 Summary

Pure jack pine forest types rather than mixedwood are most common in this seed zone. The terrain is variable with organic depressions and areas of dunes occurring within a matrix of shallow sandy soils.

G2.2 DRAFT SEED ZONE 9B

G2.2.1 Geography

This seed zone is situated in northeastern Alberta and consists of the area west of Fort McMurray including the Thickwood Hills. The zone extends from 58 05' N to 56 20' N latitude, and from 111 05' W to 114 55' W longitude. The elevation range is from 250 to 600 metres and the total area is approximately 13,970 km^2. Its boundaries fall within the Central Mixedwood Subregion of the Boreal Forest Natural Region.

G2.2.2 Topography and Soils

Most of this seed zone has level to depressional topography with areas of gently rolling ridges. Parent materials are primarily fine textured undulating lacustrine plain and sandy and gravelly tills. Poorly to imperfectly drained organic and Gleysolic soils occupy approximately 60% of the land area and peat depths of several feet have been recorded. Occasional permafrost occurs in these organic soils at 40 and 50 centimetres below the peat surface.

Mineral soils on better drained sites have Gray Luvisols on fine textured materials and Eutric Brunisols or Podzols on coarse textured materials. These mineral soils are generally in the form of islands surrounded by organic soils. Although it does not represent a large area, the Athabasca River valley is an important topographical feature in this zone and is associated with fluvial benches, level to depressional areas, gently rolling terrain and sand dunes.

G2.2.3 Climate

Five meteorological stations represent this area (Table G.2). Of these, only Fort McMurray records annual climate data. The mean June-August temperature of 14.4°C appears fairly typical for the Central Mixedwood Subregion but the average total June-August precipitation of 219.5 mm for the growing season and annual precipitation of 471.9 mm indicates greater precipitation. The mean annual temperature for Fort McMurray of -0.2°C is slightly lower than the 0.5°C reported as typical for the Central Mixedwood Subregion. The frost free period of 86.3 days and growing degree days above 10°C of 575.8 is also fairly typical for core boreal mixedwood areas.

G2.2.4 Ecology

Trembling aspen, balsam poplar and white spruce mixedwood forest types make up a major portion of the vegetation in this zone, particularly in well drained areas along the Wabasca and Athabasca rivers. These forest types are usually dominated initially by the poplars which are increasingly replaced by white spruce and balsam fir over time. Understories in these mixedwood types commonly include lowbush cranberry, beaked hazelnut, prickly rose, red-osier dogwood, marsh reed grass, sarsaparilla, dewberry, cream

colored peavine, pink wintergreen and twin flower. Feather mosses are also present and their cover increases with increasing stand age and conifer composition.

Pure stands of balsam poplar occur along watercourses and in wet depressions. Paper birch is commonly present as a minor component in mixedwood stands and occasionally forms pure stands.

Sparse black spruce forest types are found on nutrient poor acidic bogs which are common in the central part of this zone between the Wabasca and Athabasca rivers. This treed muskeg commonly has a ground cover of Labrador tea and sphagnum mosses. On richer fens, tamarack, dwarf birches, sedges and brown mosses are more common.

On dry sandy upland sites, jack pine forest types occupy the dunes and alluvial deposits and commonly have understories of lichen bearberry, low bilberry, bog cranberry and prickly rose.

G2.2.5 Summary

This seed zone is fairly typical of the core area of the Central Mixedwood Subregion. Forest types along the Wabasca and Athabasca rivers are the most productive due to better drainage while a large area in the central part of the zone is dominated by unproductive treed muskeg.

Table G.2
Summary of Climatic Data for Draft Seed Zone 9B Station

Climate Station And Elevation	Mean June-August Temp (°C)	Mean Summer Precip J-J-A (mm)	Mean Annual Temp (°C)	Mean Annual Precip (mm)	Frost Free Period (Days)	Growing Degree Days >10°C (Days)	Day Length (Longest) (Hours)
Chipewyan Lakes LO (369 m)	14.1	188.9	-	-	103	-	18
Ells River LO (610 m)	14.2	212.9	-	-	78	-	18
Fort McMurray (369 m)	15.1	216.1	-0.2	471.9	84	575.8	18
Thickwood Hills LO (604 m)	14.2	259.9	-	-	87	-	18
Mildred Lakes (310 m)	-	-	-	-	88	-	18
Mean	14.4	219.5	-0.2	471.9	86.3	575.8	18

G2.3 DRAFT SEED ZONE 10B

G2.3.1 Geography

This seed zone is situated in northeastern Alberta and consists of the low lying areas north of the Pelican Mountains, south of the Peerless Lake Highlands and east toward Fort McMurray. The zone extends from 55 10' N to 56 45' N latitude, and from 110 45' W to 115 15' W longitude. Elevations range from 360 to 700 metres with a total area of approximately 17,740 km^2. Its boundaries correspond to these of the Central Mixedwood Subregion of the Boreal Forest Natural Region.

G2.3.2 Topography and Soils

Most of this seed zone has level to depressional topography with some gently rolling ridges. Parent materials are primarily sandy alluvium and gravelly outwash materials associated with undulating morainal plain. Gray Luvisolic soils are most prevalent on fine textured parent materials, while Eutric Brunisols soils are common on coarse textured upland sites. The majority of mineral soils occur as islands surrounded by poorly drained organic and Gleysolic soils which occupy approximately 75% of the total area. Peat depth of up to three metres has been measured and permafrost has occasionally been encountered.

The zone is dissected by the Athabasca River which is associated with level to depressional bog areas, gently rolling terrain, dunes and fluvial benches. Soils covering the zone range from poorly drained organics to rapidly drained Brunisols and Podzols soils, which are associated with these landforms.

G2.3.3 Climate

There is climatic information from both seasonal and yearly meteorological stations for this zone (Table G.3). These stations have a mean June-August temperature of 14.6°C and an average total precipitation of 227.8 mm for the same period. The frost free period is 98 days long and the number of growing degree days above 10°C is 586.8 days. The mean annual temperature recorded at Fort McMurray and Wabasca is 0.2°C with mean annual precipitation of 466.1 mm.

G2.3.4 Ecology

The eastern two thirds of this zone are dominated by black spruce forest types on poorly drained acidic bogs with typical ground cover of Labrador tea and sphagnum mosses. Where nutrient conditions are richer, bog species are complemented or replaced by tamarack, dwarf birches, sedges and brown mosses.

Mixedwood forest types composed of varying amounts of trembling aspen, balsam poplar and white spruce are common in the western third of this zone and along the Athabasca

River valley. Understory vegetation in the better drained types is commonly composed of species such as low bush cranberry, beaked hazelnut, prickly rose, red osier dogwood, marsh reed grass, sarsaparilla, dewberry, cream-coloured peavine, pink wintergreen and twin flower. As the deciduous component in these stands declines over time and as canopy closure occurs with the increase of later successional white spruce and balsam fir types, the proportion of feather mosses in the understory increase. These later successional types occur but are not widespread in the area due to frequent fires.

Pure stands of balsam poplar are common along the Athabasca River valley and along streams. Paper birch is a minor component in mixedwood stands throughout the zone and occasionally forms pure stands. Jack pine forest types are frequent on coarse textured upland sites and commonly have understories of reindeer lichen, bearberry, low bilberry, bog cranberry and prickly rose.

G2.3.5 Summary

This zone has a climate which is similar to Central Mixedwood areas to the north. It is warmer and drier during the growing season than core boreal mixedwood areas to the west and has coarser textured soils and poorer drainage. Areas in the west of this zone and along the Athabasca River are productive forest lands but much of the zone is too poorly drained to support commercial stands.

Table G.3
Summary of Climatic Data for Draft Seed Zone 10B Stations

Climate Station And Elevation	Mean June-August Temp (°C)	Mean Summer Precip J-J-A (mm)	Mean Annual Temp (°C)	Mean Annual Precip (mm)	Frost Free Period (Days)	Growth Degree Days > 10 °C (Days)	Day Length (Longest) (Hours)
Fort McMurray Airport (369 m)	15.1	216.1	-0.2	471.9	84	575.8	18
Grande LO (533 m)	14.1	238.8	-	-	80	-	18
Livock LO (579 m)	14.1	243.5	-	-	-	-	18
Muskwa LO (625 m)	14.3	223.4	-	-	113	-	18
Wabasca RS (545 m)	15.2	217.1	0.6	460.2	115	597.7	18
Mean	14.6	227.8	0.2	466.1	98	586.8	18.0

G2.4 DRAFT SEED ZONE 11A

G2.4.1 Geography

This seed zone is situated in northeastern Alberta and consists of the front slopes of the Birch Mountains which extends from 57 00' N to 58 12' N latitude, and from 111 44' W to 114 36' W longitude. It represents lower elevations of the Birch Mountains lying between 450 and 925 metres and has a total area of approximately 7,470 km^2. Its boundaries correspond to the Boreal Highlands Subregion of the Boreal Forest Natural Region.

G2.4.2 Topography and Soils

The topography of the zone varies from gently rolling to hilly and parent materials are primarily clay loam to sandy loam, non-calcareous, glacial tills. Gray Luvisolic soils have developed on well-drained upland sites while Brunisols and Podzols occur on coarser textured alluvial materials. Organic and Gleysolic soils are found in wet depressional areas and cover about 30% of the land area.

G2.4.3 Climate

Climatic information for this zone is limited; four meteorological stations represent the area (Table G.4). These stations have an average June-August temperature of 12.8°C and average total precipitation for the same period of 267.5 mm. The frost free period is less than 85 days and May frosts are frequent.

G2.4.4 Ecology

Black spruce and jack pine forest types, with occasional jack-lodgepole pine hybrids at higher elevations make up a major portion of the vegetation in this zone. It is common for black spruce in this zone to occupy upland as well as wet sites. Peatland complexes composed of nutrient-poor black spruce bogs and nutrient-rich fens are common. Understory species in these forest types are commonly composed of Labrador tea and sphagnum mosses. For fens, the most common species are tamarack, dwarf birch, sedges and brown mosses. Areas of permafrost are reported for the zone.

Pure jack pine forest types on dry, sandy sites contain typical understory species such as bearberry, low bilberry, bog cranberry, prickly rose and reindeer lichen. Trembling aspen, balsam poplar and white spruce mixedwood forest types are not common in this zone and tend to be more frequent at lower elevations. Understories in these stands are fairly typical for mixedwood types but have fewer species due to the cooler climate. At higher elevations and in moister areas, these mixedwood types may be composed entirely of balsam poplar and white spruce. Paper birch is a minor component in many of these mixedwood types and occasionally forms pure stands.

G2.4.5 Summary

Seed zone 11a is part of a noncontiguous seed zone 11. It is cooler and moister during the growing season than adjacent areas at lower elevations and is dominated by coniferous black spruce and jack pine forest types. Mixedwood forest types which are more common at lower elevations and in areas of better drainage are more productive for timber than other types. The most similar seed zones are zone 11b, 11c, 11d and 11e.

Table G.4
Summary of Climatic Data for Draft Seed Zone 11A Stations

Climate Station And Elevation	Mean June-August Temp (°C)	Mean Summer Precip J-J-A (mm)	Mean Annual Temp (°C)	Mean Annual Precip (mm)	Frost Free Period (Days)	Growth Degree Days >10°C (Days)	Days Length (Longest) (Hours)
Birch Mountain LO (853 m)	12.9	268.2	-	-	88	-	18
Buckton LO (792 m)	12.3	267.7	-	-	69	-	18
Jean Lake LO (762 m)	13.2	287.1	-	-	83	-	18
Legend LO (911 m)	12.7	247.1	-	-	78	-	18
Mean	12.8	267.5	-	-	80.0	-	18

G3. LITERATURE CITED

Alberta Environmental Protection. 1994. Natural Regions and Subregions of Alberta: Summary. Publication No. 1/531. Edmonton, Alberta. 18 pp.

APPENDIX H

NATIVE PLANTS SUITABLE FOR RECLAMATION IN THE CENTRAL MIXEDWOOD SUBREGION OF THE BOREAL FOREST NATURAL REGION

Table H.1
Native Plants Suitable for Reclamation in the Central Mixedwood Subregion of the Boreal Forest Natural Region[a]

Scientific Name	Common Name	Habitat Preference		
		Soil Texture	Soil Moisture	Soil Tolerance
Grasses and Grass-like Plants				
Agrostis scabra	tickle grass	fine to coarse	mesic to dry	drought, acidic
Beckmannia syzigachne	slough grass	Medium	Wet	alkaline, flood
Bromus ciliatus	fringed brome	--	Mesic	--
Calamagrostis canadensis	bluejoint	fine to coarse	wet to mesic	acidic, flood, drought, saline
Calamagrostis inexpansa	northern reed grass	--	wet to mesic	flood
Calamagrtostis montanensis	plains reed grass	--	mesic to dry	--
Calamagrostis stricta	narrow-leaved reed grass	--	wet to mesic	--
Carex aquatilis	water sedge	Fine	Wet	alkaline, flood
Carex atherodes	awned sedge	fine to medium	Wet	drought, alkaline
Carex aurea	golden sedge	--	wet to mesic	--
Carex capillaris	hair-like sedge	--	wet	--
Carex obtusata	blunt sedge	--	mesic to dry	--
Carex raymondii	--	--	wet to mesic	--
Carex rostrata	beaked sedge	--	wet to mesic	--
Carex siccata	hay sedge	coarse	dry	--
Deschampsia cespitosa	tufted hair grass	fine to medium	wet to mesic	saline, alkaline, acidic
Elymus canadensis	Canadian wild rye	medium to coarse	mesic to dry	alkaline
Elymus innovatus	hairy wild rye	fine to coarse	mesic to dry	--
Festuca saximontana	rocky mountain fescue	--	dry	--
Glyceria borealis	northern manna grass	fine	wet	flood
Glyceria grandis	tall manna grass	fine	wet	flood
Glyceria striata	fowl manna grass	fine	wet	flood
Koeleria macrantha/cristata	June grass	medium to coarse	mesic to dry	drought, alkaline
Oryzopsis asperifolia	white-grained mountain rice grass	--	--	--
Oryzopsis pungens	northern rice grass	fine to coarse	dry	--
Phragmites australis/communis	common reed grass	fine to coarse	wet to mesic	alkaline
Poa arida	plains bluegrass	--	mesic to dry	saline
Poa glauca	bluegrass	coarse	--	--
Poa palustris	fowl bluegrass	--	wet to mesic	--
Schizachne purpurascens	purple oat grass	--	--	--
Trisetum spicatum	spike trisetum	coarse	mesic to dry	drought, acidic, alkaline

Table H.1 (cont'd)

Scientific Name	Common Name	Habitat Preference		
		Soil Texture	**Soil Moisture**	**Soil Tolerance**
Forbs				
Achillea millefolium	common yarrow	medium to coarse	wet to dry	drought, acidic
Anemone canadensis	Canada anemone	--	wet	--
Anemone multifida	cut-leaved anemone	coarse	mesic	--
Anemone parviflora	small wood anemone	--	mesic	--
Arabis lyrata	lyre-leaved rock cress	fine	dry	--
Aralia nudicaulis	wild sarsaparilla	--	wet to mesic	--
Artemisia campestris	northern wormwood	--	dry	--
Aster borealis	rush aster	medium	wet	--
Aster ciliolatus	Lindley's aster	--	--	--
Aster conspicuus	showy aster	--	--	--
Astragalus alpinus	alpine milk vetch	--	mesic	--
Astragalus dasyglottis	purple milk vetch	--	mesic	--
Astragalus striatus	ascending purple milk vetch	--	dry	--
Comandra umbellata	bastard toad-flax	--	mesic to dry	--
Cornus canadensis	bunchberry	--	mesic	acidic
Epilobium angustifolium	fireweed	fine to coarse	mesic	alkaline, acidic
Epilobium ciliatum	northern willow herb	fine to coarse	wet to mesic	alkaline, acidic
Erigeron canadensis	horseweed	--	dry	--
Erigeron glabellus	smooth fleabane	--	mesic	--
Fragaria vesca	woodland strawberry	coarse	mesic	--
Fragaria virginiana/glauca	wild strawberry	--	wet to mesic	--
Galium boreale	northern bedstraw	--	wet to mesic	--
Hedysarum boreale	northern sweet vetch	fine to coarse	mesic to dry	drought, saline, alkaline
Heracleum lanatum	cow parsnip	--	mesic	--
Heuchera richardsonii	alum-root	--	wet to mesic	--
Hieracium umbellatum	narrow-leaved hawkweed	--	dry	--
Lathyrus ochroleucus	cream-colored pea vine	medium	wet to mesic	--
Linnaea borealis	twin-flower	--	mesic	--
Maianthemum canadense	lily-of-the-valley	--	mesic	--
Melampyrum lineare	cow wheat	fine	dry	--
Mentha arvensis	wild mint	--	wet	flood
Mertensia paniculata	tall lungwort	--	mesic	--
Mitella nuda	Bishop's-cap	--	wet to mesic	--
Oxytropis splendens	showy locoweed	--	--	--
Parnassia palustris	northern grass of parnassus	--	wet	--
Petasites sagittatus	arrow-leaved coltsfoot	--	wet	flood
Potentilla pensylvanica	prairie cinquefoil	--	mesic	--

Table H.1 (cont'd)

Scientific Name	Common Name	Habitat Preference		
		Soil Texture	Soil Moisture	Soil Tolerance
Forbs - Continued				
Potentilla tridentata	three-toothed cinquefoil	fine	dry	--
Rubus arcticus	dwarf raspberry	--	wet to mesic	acidic
Rubus chamaemorus	cloudberry	--	wet to mesic	acidic
Rumex occidentalis	western dock	--	wet to mesic	--
Scutellaria galericulata	marsh skullcap	--	wet	--
Senecio pauperculus	balsam groundsel	--	wet to mesic	saline
Senecio triangularis	brook ragwort	--	wet to mesic	--
Smilacina stellata	star-flowered Solomon's-seal	--	wet to mesic	--
Solidago canadensis	Canada goldenrod	fine to coarse	mesic to dry	drought
Solidago spathulata	mountain goldenrod	--	mesic	--
Stachys palustris	hedge nettle	--	wet	--
Thalictrum venulosum	veiny meadow rue	--	wet to mesic	--
Vicia sparsifolia/americana	American vetch	medium to coarse	mesic	--
Shrubs				
Alnus crispa	green alder	medium to coarse	wet to mesic	acidic, flood, alkaline
Amelanchier alnifolia	saskatoon	medium to coarse	mesic to dry	drought, acidic, alkaline
Arctostaphylos uva-ursi	bearberry	medium to coarse	mesic to dry	drought, acidic
Cornus stolonifera	red osier dogwood	fine to medium	wet to mesic	alkaline, flood, acidic
Ledum palustre/groenlandicum	Labrador tea	--	wet	acidic
Lonicera dioica	twining honeysuckle	--	--	--
Lonicera involucrata	bracted honeysuckle	medium to coarse	wet to mesic	--
Prunus pensylvanica	pin cherry	--	mesic	--
Ribes hudsonianum	Hudson Bay currant	--	wet to mesic	--
Ribes lacustre	bristly black current	medium	wet to mesic	--
Rosa acicularis	prickly rose	fine to coarse	mesic	acidic, drought, flood
Rubus idaeus	raspberry	fine to coarse	mesic	drought, saline, acidic
Salix candida	hoary willow	--	--	saline
Salix glauca	smooth willow	fine to coarse	wet to mesic	acidic
Salix maccalliana	velvet-fruited willow	--	wet to mesic	--
Shepherdia canadensis	Canadian buffalo-berry	medium to coarse	mesic to dry	drought, saline, acidic, alkaline
Vaccinium myrtillus	low bilberry	--	mesic to dry	--
Vaccinium vitis-idaea	cow-berry	--	mesic to dry	acidic
Viburnum edule	low-bush cranberry	medium to coarse	wet to mesic	--

Table H.1 (cont'd)

Scientific Name	Common Name	Habitat Preference		
		Soil Texture	**Soil Moisture**	**Soil Tolerance**
Trees				
Larix laricina	tamarack	medium	wet to mesic	acidic
Picea glauca	white spruce	fine to coarse	mesic	acidic, drought, flood
Picea mariana	black spruce	Medium	wet to mesic	acidic
Pinus banksiana	jack pine	Coarse	mesic to dry	acidic, drought, alkaline
Populus balsamifera	balsam poplar	fine to coarse	wet to mesic	flood, saline, alkaline
Populus tremuloides	trembling aspen	fine to coarse	mesic	flood, drought, alkaline

[a] Adapted from the original table in: Gerling, H.S., M.G Willoghby, A. Schoepf, K.E. Tannas and C.A. Tannas. 1996. A Guide to Using Native Plants on Disturbed Lands. Alberta Agriculture, Food and Rural Development and Alberta Environmental Protection. 247 pp.

APPENDIX I

STANDARDS AND GUIDELINES FOR OPERATING BESIDE WATERCOURSES FROM: TIMBER HARVEST PLANNING AND OPERATING GROUND RULES

Standards and Guidelines for Operating Beside Watercourses
Prepared by Garry Ehrentraut, Northern Forest Products Ltd.

Watercourse Classification	Physical Description	Portion of Year Water Flows	Channel Development	Fish and Wildlife Concerns	Land Use Impact	Roads, Landings and Bared Areas	Watercourse Protective Buffers
Large Permanent	• Major streams or rivers • Well-defined flood plains • Valley usually exceeds 400m in width	• All year	• Unvegetated channel width greater than 5m.	• Resident fish populations. • Important over-wintering habitat. • Important feeding & rearing habitat.	• Water quality often reflects all upstream land use impacts and natural processes. • Primarily sedimentation of stream channels .	• Not permitted with 60m of the high-water mark or from water Source areas within that buffer • May be permitted within 60 to 100m of the high water mark with written approval of a Forest Officer.	• No disturbance or removal of merchantable timber within 60m of the high water mark except where specifically approved in the Annual Operating Plan.
Small Permanent	• Permanent streams • Often small valleys • Bench (floodplain) development	• All year, may freeze in the winter	• Banks and channel well-defined. • Channel width 0.5m to 5m.	• Significant insect population • Important spawning and rearing habitat. • Resident fish populations. • Overwintering for non-migratory species.	• Primarily sedimentation of stream channels. • Fish populations sensitive to situation. • Loss of streambank fish habitat.	• Not permitted within 30m of the high-water mark or from water Source areas within that buffer. • May be permitted within 30 to 100 m of the high water mark with written approval of a Forest Officer.	• No disturbance or removal of merchantable timber within 30m of the high water mark except where specifically approved in the Annual Operating Plan.
Intermittent	• Small stream channels • Small springs are main source outside periods of spring runoff and heavy rainfalls	• During wet season or storms. • Dries up during drought.	• Distinct channel development. • Usually channel is unvegetated. • Channel width to 0.5m • Some bank development.	• Food production areas. • Potential spawning for spring spawning species. • Drift invertebrate populations in pools and riffles.	• Sedimentation from bank and streambed damage will damage fish habitat down stream.	• Not permitted within 30m of the high-water mark or from water source areas within that buffer.	• Buffer of brush and lesser vegetation to be left undisturbed along the channel. • Width of buffer will vary according to soils, topography water source areas and fisheries values. • Treed buffer is not required unless specifically requested by a Forest Officer.
Ephemeral	• Often a vegetated draw	• Flows during or immediately after rain or snowfall	• Little or no channel development. • Channel is usually vegetated.	• Situation may impact fish habitat.	• Sedimentation downstream due to ground disturbance.	• Construction not permitted within a watercourse or a water source area.	• Buffer of lesser vegetation in wet gullies to be left undisturbed.

Standards and Guidelines for Operating Beside Watercourses - Concluded

Watercourse Classification	Physical Description	Portion of Year Water Flows	Channel Development	Fish and Wildlife Concerns	Land Use Impact	Roads, Landings and Bared Areas	Watercourse Protective Buffers
Water source Areas (except muskegs)	• Areas with saturated soils or surface flow	• All year • May or may not freeze in winter.	• N/A	• Potential high value to fall spawners. • Potential high use areas for terrestrial wildlife.	• Disturbance may cause stream sedimentation. • Interruption of winter flow may disrupt fish egg incubation.	• Construction not permitted unless approved in the Annual Operating Plan. • No log decks permitted • The number of stream crossings must be minimized. • No disturbance of organic duff layers or removal of lesser vegetation.	• Treed buffer of at least 20m on all streams. • No harvest of merchantable trees or disturbance of lesser vegetation unless approved by the Annual Operating Plan. • Buffer width may be altered according to its potential to produce surface water, provided it is approved in the Annual Operating Plan.
Lakes (little or no recreation, waterfowl, or sport fishing potential.	• Large water collection areas permanently filled with water	• Normally frozen in the winter.	• N/A	• Important fish bearing habitat.	• Aesthetic values may be disrupted. • Interruption of winter flow may disrupt fish egg incubation.	• Not permitted within 100m of the high-water mark without written approval of a Forest Officer.	• On lakes exceeding 16 ha in area, there will be no disturbance of timber within 100m of the high water mark except where specifically approved in the Annual Operating Plan.
Lakes (with recreational, waterfowl or sport fishing potential)	• Large water collection areas permanently filled with water	• Normally frozen in the winter.	• N/A	• Important fish bearing habitat.	• Aesthetic values may be disrupted. • Interruption of winter flow may disrupt fish egg incubation.	• For shorelines not located within reserved areas, no disturbance will be permitted within 200m of the high water mark without the written approval of the Forest Superintendent.	• On lakes exceeding 4 ha in area, there will be no disturbance or removal of timber within 100m of the high water mark except where specifically approved in the Annual Operating Plan.

APPENDIX J

WILDLIFE POPULATIONS AND HABITAT CAPABILITY IN THE OIL SANDS REGION

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J1. SUMMARY OF WILDLIFE POPULATIONS IN THE OIL SANDS REGION

Prepared by Judy Smith and Greg Wagner, BOVAR Environmental

The following is an account of wildlife species known to occur in the oil sands region. Discussion is focused on wildlife species of economic, recreational and political importance including ungulates, carnivores, furbearers, waterbirds, raptors, upland game birds and species 'at risk'.

J1.1 UNGULATES

Moose are the most common ungulate in the oil sands region. Population densities vary within the region based on habitat availability, hunting pressures and predation. In general, moose densities in northeastern Alberta are low compared to densities reported from central and northwestern Alberta. In at least part of the region, moose are known to undertake seasonal movements from upland areas to wintering areas in the Fort Hills or along the Athabasca and other major river valleys.

The oil sands region is near the northern limits of the range of both white-tailed and mule deer. Mule deer have historically been sporadically distributed across the boreal forest in northern Alberta. White-tailed deer, however, are more recent arrivals. They were first noted in the Fort McMurray area during the 1950s following the clearing of land for agriculture. Both species occur in low densities in the region. Populations are probably limited by severe winter weather conditions, including the presence of deep, crusted snow.

Elk were formerly more widely distributed in the oil sands area, but now are largely confined to areas along the Athabasca River south of Fort McMurray. Small numbers of woodland caribou are occasionally sighted in the region. Major populations, however, are largely restricted to the Birch Hills and Algar Lake area. Historically, herds of barren ground caribou made seasonal migrations as far south as Fort McMurray along the eastern boundary of the oil sands region. However, herds have not been observed in the area in over thirty years. Small herds of wood bison are occasionally observed and hunted in the oil sands region immediately south of Wood Buffalo National Park. But, major herds are mainly restricted to the park and areas north of the park.

J1.2 LARGE CARNIVORES

Coyotes are the most abundant large carnivore in the region. Timber wolves also occur. Radio-telemetry studies conducted in the late 1970s established densities at 1 animal/151 km^2, which is within the range of densities reported for wolves from other localities in North America. Activities were concentrated in open and disturbed habitats, although elsewhere wolves are more commonly associated with forested habitats. Densities of black bear in the region have been estimated at 2 to 5.6 km^2/bear, which are relatively

high estimates compared to those reported from other areas of the boreal forest. Deciduous and mixedwood forests provide the highest quality habitats for black bear in the region. The historic range of the grizzly bear includes the oil sands region. Populations are greatly diminished from the past, but there have been some recent signs that the species still occurs in the region. Trapping records indicate that historically lynx were much more abundant in the region than they are currently. However, lynx populations follow the approximately ten year population cycle of the snowshoe hare and numbers are expected to increase as hare populations rebound.

J1.3 SMALL TERRESTRIAL FURBEARERS

The snowshoe hare is the most common terrestrial furbearer in the region, but undergoes dramatic population cycles so numbers can vary from year to year. The snowshoe hare is a staple prey species of the coyote, lynx and fisher, and affects population cycles in at least the first two species. The hare is also the most commonly trapped and hunted species in the region. Red squirrels are also abundant, occurring in forested habitats with a major pine or spruce component. Ermine are considered to be common to abundant and least weasels uncommon in the oil sands region. Both species are important to the trapping industry. These species show a preference for open tamarack-bog birch habitats, followed by black spruce-tamarack and cleared peatland habitats. Recently, marten populations have increased in northeastern Alberta. The species occurs mainly in continuous tracts of closed canopy, mature coniferous or mixedwood forests and, to a lesser extent, in open black spruce bogs and hardwood stands. The fisher is also considered to be an uncommon species that is trapped with some regularity in the region. Red fox also occur in the region, but in relatively low densities. The low numbers are attributable to competition with wolves and coyotes. Wolverine, which have large home ranges (200 to 500 km^2), also occur in low densities.

J1.4 AQUATIC FURBEARERS

Beaver comprise a significant proportion of the total number of furbearers trapped in the region. They are widely distributed, occupying virtually all of the low gradient streams and standing bodies of water in the area. Muskrats occur in relatively low densities and are largely restricted to a few lakes and wetlands within the region. Mink densities are relatively high and fur harvest data indicates that mink are consistently trapped in low numbers within the Fort McMurray area. The species shows a preference for riparian shrub habitats. River otter occur in low numbers throughout the region, with the exception of the higher densities observed around the Calumet leases.

J1.5 OTHER MAMMALS

Regionally, seven species of mice and vole have been recorded. The white-footed deer mouse, red-backed vole and meadow vole are the most abundant species, while meadow jumping mouse, northern bog lemming, yellow-cheeked vole and heather vole occur in much lower numbers and are frequently restricted to specialized habitat types. Five species of shrew - masked, pygmy, dusky, water and arctic - are also expected to occur in the region. Of these, the masked and pygmy shrew are the most common. Several other species of mammals are known or expected to occur in the oil sands area. These include five species of bat (little brown bat, big brown bat, hoary bat, Keen's bat, and silver-haired bat), badger, raccoon, woodchuck, porcupine, northern flying squirrel and chipmunk. Although some are relatively abundant in the region, none are of particular economic significance.

J1.6 WATERBIRDS

The Peace-Athabasca Delta, a major staging, breeding and moulting area for waterbirds, lies to the north of the oil sands region. Substantial numbers of migrating waterbirds therefore pass through the region in the spring and fall on their way to and from the delta. There is, however, relatively small amount of wetland habitat in the region and waterbird use is restricted to a few key wetlands. Three lakes have been identified as regionally important: McClelland and Ronald lakes for staging waterfowl, and Namur Lake as a breeding location for California gulls. Seven areas or lakes have been identified as locally important: Kearl, Audit and Algar lakes for staging ducks; Algar Lake for moulting ducks; the Birch Mountains uplands for migrating waterbirds and breeding trumpeter swans; Namur Lake for breeding white pelicans and herring gulls; and Gardiner and Eaglenest lakes for non-breeding concentrations of pelicans.

Most of the region is not heavily utilized by waterfowl during spring migration, except for a few lakes and some areas on the Athabasca River. Areas supporting the highest spring densities of waterbirds include McClelland and Little McClelland lakes. The region is used to a greater extent by fall migrants. Kearl, McClelland, Little McClelland and Gordon lakes are used by large numbers of diving and dabbling ducks, American coots and tundra swans. Numbers of staging fall migrant, however, vary substantially between both years and areas. The main migrant waterbird groups in the region are diving ducks, dabbling ducks, American coot and gulls. Little information is available on the migration or staging of other waterbird species in the region. Low numbers of migrant shorebirds, grebes, loons, swans and geese have been recorded over the last twenty years.

Included among the species migrating through the area is the endangered Whooping Crane, which nests in and near Wood Buffalo National Park and winters along the coast of Texas. During the mid-1970s, whooping cranes (lone birds or small flocks) were observed flying over Lease 17 and in 1974 two birds were flushed from Ruth Lake.

There is limited waterfowl production in the oil sands region, with the exception of three lakes, McClelland, Saline and Horseshoe, where mean densities of breeding pairs and broods are comparable to the densities associated with the prairie potholes. Most other wetlands in the region are characterized by low fertility and sparse vegetation, which create poor availability of food, nesting cover and brood cover.

Ten shorebird species are known to breed in the region, with greater and lesser yellowlegs, killdeer and spotted sandpiper being the most common.

J1.7 RAPTORS

Twenty-four species of raptors are known to occur as migrants, seasonal residents or permanent residents in the Fort McMurray region. Specific surveys have been conducted in the region to locate large and rare raptors (i.e., bald and golden eagle, osprey, peregrine falcon). Bald eagle nests have been found around several lakes in the region, with the greatest densities of nesting eagles occurring in the Gardiner Lake area. Ospreys are considered rare in the region, although a few nest sites are located around Namur Lake. Peregrine falcons and golden eagles only occur as migrants.

Common breeding raptors include the red-tailed hawk, broad-winged hawk, northern harrier, American kestrel, great horned owl, northern hawk owl and great grey owl. The red-tailed hawk prefers an interspersion of mature forest and grassland; it uses the muskeg and marshes for hunting, and the forest edge for resting. The broad-winged hawk is rarely seen in the open and prefers deciduous habitat or more open mixedwood areas with numerous low perches; it avoids disturbed areas and human inhabitation. Northern harriers hunt and nest along marshy areas and cutlines. American kestrels nest in tree cavities and prefer open areas with scattered perches. Great horned owls and northern hawk owls utilize forests and forest edge. Great grey owls nest in forested areas adjacent to bogs and fens, which are inhabited by its favourite prey item - the meadow vole. Other species that are known or thought to breed in the region include: sharp-shinned hawk, goshawk, merlin, short-eared owl, long-eared owl and boreal owl.

In addition to golden eagle and peregrine, migrants through the region include: Cooper's hawk, Swainson's hawk, rough-legged hawk, and gyrfalcon. Snowy owls are winter residents in the region.

J1.8 UPLAND GAME BIRDS

Four species of upland game birds occur in the region. Three of these species are year-round residents. The spruce grouse is the most abundant species, with coniferous dominated forests being the preferred habitat for much of the year. Deciduous or mixedwood forest with dense shrub understories are occupied by ruffed grouse, which are

the second most abundant species in the region. Smaller numbers of sharp-tailed grouse occupy grassy and/or shrubby areas and are often found in recently cleared habitats.

The willow ptarmigan is a winter resident and reaches the southern limits of its wintering range in the tar sands region. They are most often found in habitats with a willow component or in trembling aspen and riparian communities.

J1.9 OTHER BIRDS

Other bird species occurring in the region are representative of four taxonomic groups (goatsuckers, kingfishers, woodpeckers and passerines). More than 80 species belonging to these groups have been observed in the oil sands region as migrant, breeding or overwintering species. Goatsuckers and kingfishers are represented by one species each, the common nighthawk and belted kingfisher, respectively. Seven species of woodpecker have also been encountered. Passerines are represented by more than 70 species. Over half of these are neotropical migrants.

Breeding bird surveys have been conducted in a variety of vegetation communities in the region. The numerically dominant species recorded during these surveys include: Tennessee warbler, least flycatcher, American redstart, ovenbird, Swainson's thrush, chipping sparrow and palm warbler. The highest densities of breeding birds have been recorded in mature, mixedwood forest communities. In contrast, jack pine stands contained the least number of breeding birds.

J1.10 REPTILES AND AMPHIBIANS

Three species of amphibians, wood frog, striped chorus frog and the Canadian Toad, are known to occur in the oil sands region. A fourth species, western toad, likely occurs along the Athabasca River. The red-sided garter snake is the only reptile species known to occur in the region. It has been recorded at Kearl Lake and in the Birch Mountains. The absence of this species in other parts of the region may reflect a lack of landforms suitable for hibernacula.

J1.11 SPECIES AT RISK

Several species occurring in the region are identified as being 'at risk' either nationally or provincially. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is responsible for identifying species or populations that are 'at risk' in Canada. Under the COSEWIC system 'at risk' species are designated under the following categories: endangered, threatened, and vulnerable. Alberta Environmental Protection (AEP) has also assigns status rankings to all wildlife species occurring in the province. Under the Alberta system 'at risk' species have been assigned to red and blue list categories. Red list species are considered at risk of extirpation within the province. The blue list is comprised of species that may be at risk of extirpation in the province. Species on the Yellow B list

are considered to be naturally rare but not in decline; naturally rare and have clumped breeding distributions or associated with habitats that are or may be deteriorating. The following table presents national and provincial status designations for 'at risk' species occurring in the oil sands region.

Species	COSEWIC Ranking	Alberta Environmental Protection Ranking (Wildlife Management Division 1996)
Wood Bison	Threatened	Red
Grizzly Bear	Vulnerable	Blue
Woodland Caribou	Vulnerable	Blue
Wolverine	Vulnerable	Blue
Peregrine Falcon	Endangered	Red
Whooping Crane	Endangered	Red
Caspian Tern	Vulnerable	Yellow B
Bay-breasted Warbler	Not Designated	Blue
Black-throated Green Warbler	Not Designated	Blue
Cape May Warbler	Not Designated	Blue
Short-eared Owl	Vulnerable	Blue
Trumpeter Swan	Not Designated	Blue
Canadian Toad	Not Designated	Red

J2. SELECTION OF TARGET WILDLIFE SPECIES

Prepared by Judy Smith and Greg Wagner, BOVAR Environmental

The justification for selecting the following species of wildlife as target species in order to define design criteria for reclaimed landscapes is presented below.

Moose. The moose is the most abundant ungulate species in the oil sands region. It is an economically important game animal for both subsistence and recreational hunting, and is a preferred species for wildlife viewing and photography. Moose are important in the food chain, providing food for predators, particularly the wolf, and scavengers in the region. They are largely browse-dependent, occupying a variety of forest types that provide edges or disturbed areas of early successional vegetation. The shrub and ground strata of deciduous, mixed and coniferous forests and shrublands are used for both food and cover. Moose are on the Green List in Alberta (Wildlife Management Division 1996).

Black Bear. The black bear is an abundant species in the region and is important for both recreational and subsistence hunting. Black bears are large, solitary omnivores that occupy large home ranges through the forested regions of North America. Habitat use by black bears is influenced primarily by the seasonal availability of food and by proximity to cover. It is dependent on a mosaic of habitat types, particularly mid-successional to mature deciduous and mixedwood forests with productive herbaceous and shrub understories. The black bear is on the Green List in Alberta (Wildlife Management Division 1996).

Snowshoe Hare. The snowshoe hare is common and widely distributed resident of the region, and provides an important food source for subsistence trappers and recreational hunters. This herbivore is an important prey species for carnivores in the area, including lynx, coyote, marten and fisher. Young forests with well-developed understories that provide abundant food and cover are the preferred habitat. It is on the Green List in Alberta (Wildlife Management Division 1996).

Red Squirrel. The red squirrel is widely distributed across the boreal forest of North America. In the northern part of its range, food availability is the most important factor determining habitat selection. Although red squirrels consume a variety of different items, spruce generally constitute the largest part of the diet, particularly in winter. In the oil sands area, the red squirrel is commonly found in mature forest communities dominated by coniferous species, particularly white spruce, and, to a lesser degree, black spruce. It is extensively trapped in the region and is an important prey species for a number of carnivores and raptors. The red squirrel is on the Green List in Alberta (Wildlife Management Division 1996).

Ruffed Grouse. The ruffed grouse is an important game bird for both recreational and subsistence hunters. Grouse is an important prey species in the area. The ruffed grouse is a non-migratory, widely distributed species, occurring in a broad band of deciduous and

mixed deciduous-coniferous forest habitats across North America. Habitat use is influenced by the proximity and quality of cover and by the seasonal availability of food. In Alberta, Ruffed Grouse primarily occupy aspen forest utilizing the ground, shrub and tree canopy strata for obtaining food and cover. The ruffed grouse is a Green Listed species in Alberta (Wildlife Management Division 1996).

Fisher. The fisher is a large, arboreal member of the weasel family that was formerly widely distributed across forested areas in Canada and western and northeastern parts of the U.S. Population in the southern parts of its range have been greatly reduced because of overharvesting and habitat loss. In the oil sands area it typically occurs in mature coniferous dominated forests with a closed canopy. It is an opportunistic feeder and its diet includes small mammals, birds and carrion. When available, snowshoe hares make up a large part of the diet. It is also a specialized predator of the porcupine. Fisher are an economically important species to the trapping industry and are frequently harvested in the oil sands area. In Alberta, the fisher is designated as Yellow B List species (Wildlife Management Division 1996)

Great Gray Owl. Great Gray Owls are distributed across the boreal forests of North America and Eurasia where they occur in coniferous, deciduous, and mixed forests, typically along forest margins in muskegs, marshes, and wet meadows. The Great Gray Owl as previously considered vulnerable across its Canadian range, but was removed from the COSEWIC list in 1996. The species is on the Yellow List in Alberta (Wildlife Management Division 1996).

Microtines: Red-backed Vole. The distribution of the red-backed vole closely coincides with the boreal forests throughout North America. Although this species occupies a wide range of plant communities, it is most common in mature forests. In northern Alberta, they occupy a variety of habitats, utilizing both the ground and shrub strata for obtaining food and cover. They avoid fields, clearings, and other unforested habitats unless an abundance of protective ground litter and shrub cover is present. Red-backed voles are an important prey species for various carnivores and raptors. They are on the Green List in Alberta (Wildlife Management Division 1996).

Microtines: White-footed Deer Mouse. The white-footed deer mouse is one of the most widely distributed small rodent species in North America. It is a ubiquitous species that occupies a variety of habitat types ranging from grasslands to forested communities. In the oil sands region it most frequently occurs in balsam poplar and mixed wood forests and early successional habitats. The presence of dense shrub and ground cover appears to be a pre-requisite for its occurrence in these areas. The deer mouse is an important prey species of hawks, owls, weasels and foxes as well as an important predator of insects detrimental to regenerating and mature forests. This species is on the Green List in Alberta (Wildlife Management Division 1996).

Passerines: Cape May Warbler. The Cape May Warbler is a tree-nesting wood warbler of the boreal forest. Cape May Warblers breed in mature white spruce stands within coniferous and mixedwood forests, preferring open stands and stand edges. This species is on the Blue List in Alberta (Wildlife Management Division 1996).

Passerines: Ovenbird. The ovenbird is a neotropical migrant that breeds in forested areas of Canada and the northeastern U.S. It is a fairly common summer resident in the oil sands region inhabiting mature deciduous or mixed wood forests with limited understory development. They feed and nest on the ground. Ovenbirds winter in tropical regions from the Gulf of Mexico to northern Columbia and Venezuela. The ovenbird is on the provincial Green List (Wildlife Management Division 1996).

Passerines: Warbling Vireo. The warbling vireo is a neotropical migrant that breeds in boreal, subalpine and deciduous forest communities throughout Canada and the U.S. It inhabits mature deciduous forests with open canopies and well developed understories. Nests are generally built in the upper canopy of large deciduous trees. The species is insectiverous and generally forages in the shrub stratum of forests or edge areas adjacent to forests. They often feed on hairy caterpillars, which are generally avoided by other species. It winters in central America from Mexico to Guatemala. The warbling vireo in on the Green List in Alberta (Wildlife Management Division 1996).

J3. GENERAL HABITAT REQUIREMENTS FOR TARGET WILDLIFE SPECIES

Prepared by Greg Wagner and Wayne Condon, BOVAR Environmental

In the majority of cases, habitat suitability is governed by broad biological and physical characteristics such as shrub or tree canopy cover, slope and topographic characteristics. The following section outlines the habitat requirements for the selected terrestrial target wildlife species. The information has been divided into: food requirements, cover requirements, special habitat requirements, and landscape components.

J3.1 MOOSE

J3.1.1 Food Requirements

- Food and cover are provided by the shrub and ground strata of deciduous, mixed and coniferous forests, as well as shrubland habitat types.
- During the fall/winter season, deciduous browse is used almost exclusively, although actual plant species composition of the diet may vary between areas.
- In the spring/summer season, herbaceous (i.e., forbs, graminoids) and aquatic vegetation, in addition to deciduous browse species, are frequently important dietary items. However, the degree to which these items are utilized varies widely from area to area.
- Of all the browse species known to be utilized by moose, various willow species are consistently reported to be one of the most utilized shrubs throughout the North American range. Within the oil sands area, willow, saskatoon, red-oiser dogwood, low-bush cranberry, birch, alder, chokecherry, pincherry and, to a lesser degree, aspen and balsam poplar are important browse items.

J3.1.2 Cover Requirements

- For much of the year, habitats selected for their food producing abilities also provide moose with adequate cover, particularly against predators.
- In winter, moose demonstrate preferences for areas supporting both high browse yield habitats and mature coniferous forests offering thermal cover and reduced snow depths.
- In summer, lakes and ponds which may be used as aquatic foraging areas also offer open-water relief from insect harassment and high temperatures.

J3.1.3 Special Habitat Requirements

- Calving areas are predominately located in isolated muskegs, riparian areas, or marshy sites interspersed with islands and isolated forest patches. Often such areas are associated with lakes, streams or marshes.

- Home range size varies based upon age, sex and seasonal use. Seasonal home ranges seldom exceed 5-10 km^2.

- Snow depths > 90 cm can severely restrict movement. However, within the oil sands area, mean snow depths rarely reach these levels and probably plays a minor role in habitat selection.

J3.1.4 Landscape Components

- In general, an interspersion of habitat types, rather than a homogenous vegetation community, is considered prime moose habitat, since such an interspersion ensures that adequate cover and forage are located nearby.

- Typically, moose prefer edge habitats spending most of their foraging time within 100 m of cover and are rarely seen more than 200 m from foraging areas.

- Optimal interspersion of foraging and cover areas is a ratio of 65:35.

- Moose may undergo seasonal migrations, although migratory tendencies may vary widely within and between geographical areas. In at least part of the oil sands region, moose make seasonal movements between summering areas in uplands and wintering areas along major river valleys. The existence of travel corridors between seasonal habitats is therefore an important factor determining the overall habitat suitability of a region. Although detailed studies are lacking, travel corridors at least 500 m in width will permit migrations between seasonal habitats.

- The presence of roads and trails in an area may cause a reduction in moose densities because of the occurrence of moose/vehicle collisions and increased hunting or predation pressures. Generally, hunting pressures are greatest within 1 km of a road or trail.

- Currently, the literature contains little or no information on the minimum area requirements of moose. However, even if such information existed minimum area requirements would probably vary widely from area to area and from year to year based on the availability and dispersion of food and cover over time.

J3.2 BLACK BEAR

J3.2.1 Food Requirements

- Black bears are omnivorous and consume a wide variety of foods; however, in the boreal forest a major portion of the diet consists of herbaceous plants and berries.

- During the early spring, following the denning period, black bears select open areas where they feed on newly emergent vegetation, particularly grasses, sedges and horsetails.
- With the progression of summer, dietary preference switches to berries, nuts, insects and a variety of herbs.
- Berries are the preferred late summer/fall food because of their high sugar content and digestibility.
- Habitat selection is closely tied to food availability, particularly the availability of berries.

J3.2.2 Cover Requirements

- For much of the year, habitats selected by bears for their food producing capabilities also provide adequate escape cover.
- Dense shrub or tree cover is used to escape from predators (e.g., other bears and wolves). Black bears also commonly bed in dense shrub communities.
- Black bears will also climb trees to escape predators. Trees with diameters at breast height of at least 15-20 cm are required to support the weight of a climbing bear.
- In the spring, black bears often feed in open areas with little or no cover. However, the use of open areas decreases at distances greater than 200 m from escape cover.

J3.2.3 Special Habitat Requirements

- Typically, black bears select dens located on steep slopes with north or east aspects in mature forests, however, they will also den in level areas of deciduous forests.

J3.2.4 Landscape Components

- Habitat interspersion increases habitat quality in an area. Areas including open, early successional areas (where newly emergent spring vegetation is available) adjacent to forested areas (providing escape cover and berry-producing plants) represent ideal habitat conditions.
- Currently, the literature contains little or no information on the minimum area requirements of black bear. However, even if such information existed minimum area requirements would probably vary widely from area to area and from year to year based on the availability and dispersion of food and cover over time.

J3.3 SNOWSHOE HARE

J3.3.1 Food Requirements

- The diet of the snowshoe hare varies seasonally. In late fall and winter, hares forage primarily on buds, twigs, bark, conifer needles and the evergreen leaves of woody plants.
- In the summer, the diet consists of a variety of leaves, herbs and green plant material.
- Several species of plants are known to be unpalatable, limiting habitat use in areas dominated by such species. Unpalatable species include black spruce, Labrador tea, low-bush cranberry, bracted honeysuckle and snowberry.

J3.3.2 Cover Requirements

- Snowshoe hare occur in pure coniferous, pure deciduous, or mixedwood forests.
- The most important aspects of habitat is a dense understory cover (50-60%) at a height of 1-3 metres to serve as escape cover and as a winter food supply.
- Deciduous stands dominated by aspen, balsam poplar and paper birch comprise the best habitat for snowshoe hares, although coniferous habitat provides better thermal protection during winter.
- Areas with 16 320+ stems/ha (shrubs and trees) provide adequate cover (and food).
- Open areas are considered poor habitat because of increased exposure to predation, decreased forage availability and reduced thermal cover.
- In the boreal forest, high quality early successional habitats regenerate following clearcutting or fire.

J3.3.3 Landscape Components

- Habitat quality increases with increased habitat dispersion. A patchy habitat mosaic, providing dense thickets for winter use and more open summer range, allows hares to shift range use seasonally to take advantage of changing environmental conditions.

J3.4 RED SQUIRREL

J3.4.1 Food Requirements

- Food is the single most important factor influencing the distribution of the red squirrel.
- Red squirrels are omnivores, eating a variety of seeds, nuts, berries, tree bark, fungi, insects, birds eggs, young birds and mice.
- The seeds of white and black spruce are the most important dietary item and influence reproduction and territory size. White spruce seed crops are variable from year to year, but provide a high quality food source. Black spruce seeds are of lower nutritive value, but crop production is relatively stable on an annual basis.
- During late summer and fall, red squirrels store cones in caches, often around the base of large spruce trees, under fallen logs, or in cavities of large snags.

J3.4.2 Cover Requirements

- Optimum cover for red squirrels occurs in mature, dense coniferous forests with greater than 50% canopy closure which provide winter food, nesting sites, thermal cover, moisture, and shade for food storage.
- Mature white spruce forests, followed by black spruce dominated forests, provide the most suitable habitat for red squirrels in the oil sands area.

J3.4.3 Special Habitat Requirements

- Red squirrel territorial requirements are highly variable, being heavily dependent on food availability. Reported densities range from 1 squirrel/0.5 ha to 1 squirrel/4.8 ha.

J3.5 RUFFED GROUSE

J3.5.1 Food Requirements

- Ruffed grouse are omnivores, feeding largely on buds, twigs, forbs, fruits, berries, and insects. Diet varies throughout the year based on the availability of foods.
- As berries, fruits and seeds become available in summer, preference is shown towards strawberries, raspberries, cherries, juneberries and sedges.

- The fall diet is comprised mainly of berries, including: cranberries, red-oiser dogwoods and roses.

- Buds, twigs and catkins of aspen and willow, supplemented with overwintering berries, are winter food staples. The use of these foods persists into early spring.

- Insects comprise only a small portion of adult food, however, the diet of chicks consists of about 90% invertebrates until about eight weeks of age.

J3.5.2 Cover Requirements

- Ruffed grouse occupy a variety of climax and successional forest community types in North America. However, the most important factor in habitat selection is the presence of a substantial deciduous tree component, particularly aspen and birch, in the tree canopy.

- In Alberta, ruffed grouse primarily occupy aspen forests with dense understories of berry-producing shrubs.

- Young aspen stands first become occupied by ruffed grouse about 4 to 12 years after regeneration following logging or fire, when trees are 8-10 m tall and stem densities are less than 14 800/ha. Grouse continued to use the habitat throughout the year for the next 10 - 15 years, until stem densities drop below 800/ha.

J3.5.3 Special Habitat Requirements

- Females typically nest in dense stands of older aspen with an open canopy and understory. Nests are usually located within 15 m of a forest opening.

- Females with broods show a preference for brushy habitat with dense escape cover nearby. Small clearings in deciduous forest, 1/10 to 1/2 hectare in size, are important brood rearing areas.

- Male ruffed grouse select territories where they display to females from raised structures on the forest floor, usually on trunks and fallen trees. Drumming sites are associated with areas of forests where woody stems are denser, the canopy cover is predominantly deciduous, the coniferous cover is very young white spruce and the shrub canopy cover is located well above the ground.

J3.6 FISHER

J3.6.1 Food Requirements

- Fisher will consume a wide variety of food, including small mammals, invertebrates, large mammal carrion, and a variety of birds.
- Snowshoe hare are a primary prey species which may, in conjunction with cover requirements, determine fisher abundance. Fishers will switch primary prey species in years of low hare availability/abundance.
- The fisher is also a specialized predator of the porcupine.

J3.6.2 Cover Requirements

- Fishers require mature to old forests with dense canopy closure (80-100%).
- Coniferous and mixedwood stands, with 50-80+% coniferous species composition, are the most suitable habitats for fishers.
- Pure deciduous stands and stands with more than 70% deciduous cover are avoided. Clearcuts and open forests are also avoided.
- Important stand level characteristics associated with old forests include: hollow logs, snag cavities, brush piles and snow dens which are used as resting areas.

J3.6.3 Special Habitat Requirements

- Maternity dens are almost always located in tree cavities, and minimum diameter at breast height for maternity den trees is 51 cm.
- Movements may be restricted by soft, deep (> 20 cm) snow.

J3.6.4 Landscape Components

- Annual home range size vary considerably. Values from 6.6 to 78.2 km^2 have been reported.
- Male fishers occupy larger territories than females.
- Currently there are no estimates in the literature regarding minimum area requirements of fishers.

J3.7 GREAT GREY OWL

J3.7.1 Food Requirements

- Great grey owls primarily prey upon small mammals, particularly rodents.
- Meadow voles dominate the diet of the great grey owl over most of the owl's range, particularly in the northern boreal forest. Nest site productivity and habitat selection are closely tied to the availability of meadow voles.

J3.7.2 Cover Requirements

- Great grey owl breeding habitat generally consists of extensive forest interspersed with sphagnum bogs, muskeg and other open areas.
- Nesting commonly occurs in stands of mature poplar adjacent to muskegs. Islands of poplars amid stands of spruce or pine are common breeding locations, as are groves or marginal strips of often-stunted tamaracks in wetter sites.
- Foraging habitat closely corresponds to areas occupied by meadow voles, which includes moist grass/sedge openings and open herbaceous forest habitats. The primary cover requirement of the meadow vole is the availability of dense, grassy vegetation. In the oil sands area, meadow voles are most abundant in areas with dense ground cover of either successional herbaceous plants or graminoids. Meadow voles also prefer wet to moist soil conditions (soil moisture exceeding 30%).

J3.7.3 Special Habitat Requirements

- Perches must be available in foraging areas as hunting from the ground or during flight is rare.
- Great grey owls do not build their own nests and thus must rely on abandoned hawk and raven stick nests or natural depressions on broken-topped snags or stumps for nest sites.

J3.7.4 Landscape Components

- Typically, great grey owls are reliant on interspersion of open, grassy areas for foraging, and mature forested areas for nesting. These two habitat conditions must therefore occur adjacent to one another to create suitable nesting habitat.
- In almost all cases nests are within 500 m of preferred foraging areas.

J3.8 MICROTINES: RED-BACKED VOLE

J3.8.1 Food Requirements

- Red-backed voles are omnivorous, feeding largely on forbs, shrubs, berries lichens, fungi and insects.
- Diet is seasonally variable.
- During the winter, overwintering fruits, small twigs, buds and lichens are staples of the diet.
- Overwintering berries are important dietary items in early spring; newly emerged berries, leaves of trees and shrubs, mosses, lichens, fungi, and horsetails are important foods from late spring to fall. In some areas, fungi can make up a large part of the summer diet.

J3.8.2 Cover Requirements

- Although this species occupies a wide range of plant communities, it is most common in moist, mature forest with relatively dense shrub canopies and abundant litter, moss and deadfall.
- Clearings and other unforested habitats are avoided unless an abundance of protective ground litter and shrub cover is present.

J3.8.3 Special Habitat Requirements

- Red-backed voles require a high daily intake of water. Consequently, the species is often restricted to low, wet areas or to areas where abundant succulent food is available.
- High litter abundance (i.e., leaves, needles, organic mulch) is commonly associated with vole habitat suitability.

J3.8.4 Landscape Components

- A minimum of 2 ha of suitable habitat may be required before an area will be occupied. Red-backed voles have limited mobility and poor dispersal abilities through open habitats to new areas, hence, the need for continuous habitat.

J3.9 MICROTINES: DEER MOUSE

J3.9.1 Food Requirements

- Food habits of the deer mouse can best be described as opportunistic and omnivorous. Regular seasonal shifts in diet are typical.
- Arthropods typically make up a large portion of the diet, particularly in the early spring.
- Berries, fruits or seeds of grasses, shrubs and trees are used as they become available and gradually comprise more of the diet in the late summer and fall.
- When available, fungi may also form a large part of the summer diet.
- In the oil sands area, willow leaves are an important dietary item during the late summer and fall.
- During the fall and winter, the diet largely consists of the seeds and fruits of grasses, shrubs and trees. Seeds of conifers may also be consumed in the winter in forest habitats.
- In the oil sands area, willow bark also appears to be an important winter food.
- Conifer needles may be eaten during periods of deep snow.

J3.9.2 Cover Requirements

- Deer mice are widely distributed and show few restrictions in habitat use.
- The species occurs primarily in woodlands and brushlands, but it also occurs in open areas such as grasslands and early successional habitats.
- Preferred habitats consist of forested areas with dense shrub and ground cover.
- In the oil sands area, deer mice are most abundant in forests with a dense understory dominated by currant, dogwood, alder or raspberry; a dense ground cover of horsetail and a variety of herb species; moderate to thick accumulations of litter and deadfall; an absence of grass/sedge cover; and dense vertical plant cover up to a height of 1.5 m.

J3.9.3 Special Habitat Requirements

- Habitat use may be influenced by interspecific and intraspecific competition. In particular, deer mice may be excluded from grassland areas through competition with meadow voles.

J3.10 PASSERINES

Optimal habitat for many passerines has a high structural diversity both vertically and horizontally in the landscape. There are many species restricted to a single habitat type. These species are considered habitat specialists.

J3.10.1 Food Requirements

- The Cape May warbler is primarily an insectivore, although it may feed on a variety of invertebrates and other materials. Numbers of Cape May warblers have been positively correlated with outbreaks of spruce budworm.
- Ovenbirds are insectivorous ground foragers and feed on a variety of invertebrate species.
- Warbling vireos are insectivores and eat a number of invertebrates including hairy caterpillars, which are avoided by many other species. Feeding generally occurs in shrubs.

J3.10.2 Cover Requirements

- Cape May warblers breed and nest in mature white spruce stands (> 60 years old) within coniferous and mixedwood forests, preferring open stands and stand edges.
- During the breeding season, male Cape May warblers select tall conifers that rise above the rest of the forest for singing perches.
- Ovenbirds are primarily associated with mature, closed canopy deciduous and mixedwood forests with little or no shrub cover. Open areas in forests are avoided.
- Warbling vireos are associated with old deciduous (60+ years) forests or aspen thickets within mixedwood forests. Forests with an open canopy and well developed shrub understory are preferred.

J3.10.3 Landscape Component

- Ovenbirds are a habitat size dependent species that are restricted to forest patches > 4 ha in area.
- Habitat quality for the warbling vireo improves in edge areas where dense shrub/sapling areas (foraging areas) are located adjacent to mature deciduous forests (nesting areas).

J4. ECOSITES AND LANDSCAPE PATTERNS THAT WILL PROVIDE HABITAT FOR TARGET WILDLIFE SPECIES

Prepared by Greg Wagner, BOVAR Environmental

The ecosites and landscape patterns on the reclaimed oil sand leases that would meet the habitat requirements of the target wildlife species are outlined below:

The value of each of these ecosites, with their associated ecosite phases and plant communities, for the target wildlife species are discussed below. Habitat suitability index models have been developed for the oil sands region for some of the targeted species. For these species, habitat suitability indices have been determined for various ecosite phases and vegetation communities. Under this format, an HSI value of 1.0 would be assigned to the habitat conditions that are considered optimal, and 0.0 would be assigned to habitat conditions that are not suitable for a particular species. In the following text, habitat suitability is discussed only in relation to ecosite phases. A number of vegetation communities can be represented under an ecosite phase, and habitat suitabilities can vary for each vegetation community within an ecosite phase. As such, an ecosite phase may be shown as having both high and moderate suitability for a species based on habitat suitability rankings for various vegetation communities that are representative of a particular ecosite phase.

For other target species, habitat suitability index models have not been developed for the oil sands region. For these species, a qualitative ranking has been assigned to various vegetation communities based on the habitat requirement of each species. These qualitative rankings are also presented in relation to ecosite phases. The palatability of the shrub and herbaceous plant species found within ecosites that can be supported on reclaimed sites, based on Beckingham and Archibald (1996), is presented in Table J.1.

J4.1 MOOSE

J4.1.1 Food and Cover Requirements

Food and cover for moose are provided by deciduous, mixed wood and coniferous forests and shrubland habitat types. Diet is seasonally variable (Table J.1). In the spring/summer season, herbaceous and aquatic vegetation, and deciduous browse are important. During the fall and winter the diet is made up almost exclusively of tall deciduous browse species. Within the oil sands region, reclamation activities can create a variety of vegetation communities important to moose (Table J.2). These vegetation communities are representative of the following ecosite phases:

- High Suitability Habitats - aspen/low-bush cranberry (d1) and aspen/white spruce/low bush cranberry (d2) ecosite phase.

- Moderate Suitability Habitats - jack pine-aspen/blueberry (b1); aspen/low-bush cranberry (d1); aspen-white spruce/low-bush cranberry (d2); white spruce/low-bush cranberry (d3); white spruce/dogwood (e3); and, to a lesser extent, aspen-white spruce/blueberry (b3) and white spruce-jack pine/ blueberry (b4) ecosite phases.

J4.1.2 Landscape Component

Moose occupy relatively large seasonal home ranges (5-10 km^2) and on an annual basis are dependent on a mosaic of habitat types. Habitat interspersion, therefore, plays an important role in determining overall habitat quality and the following factors should be incorporated in the development of re-constructed landscapes for moose:

- Moose show a preference for edge habitats, including areas with high browse yields (shrub and successional habitats with tall, preferred browse species) adjacent to forests that provide escape and thermal cover and reduced snow depths during the winter. Habitat quality for moose can be improved by locating successional or shrub dominated communities (associated with shrubby rich fen ecosite phases) adjacent to forest communities with high cover values. To maximize habitat quality, foraging areas should be developed as 100 m strips adjacent to 200 m forest strips.
- Muskeg, riparian and marshy areas are seasonally important as calving areas. Reclamation habitats should be developed in proximity to such areas. In particular, habitat quality in calving areas can be improved by developing isolated forest patches or forest islands within or adjacent to muskeg and marshy habitats.
- During the open-water season, lakes and ponds are used as foraging areas and provide relief from insect harassment and high temperatures. Lake and pond habitats are currently somewhat limited in the oil sands area, however, such habitats are being developed to a greater extent in reclaimed areas. To improve habitat quality for moose, extensive littoral zones (water depths of 0-3 m) should be developed on these wetlands to promote the establishment of aquatic vegetation. Vegetation communities with high habitat suitability should also be established adjacent to existing and reconstructed wetlands.
- Habitat quality for moose is reduced in areas within 1 km of roads.
- Within parts of the oil sands area, moose make seasonal migrations between summer habitats in upland areas and wintering habitats along major river valleys or in the Fort Hills. Travel corridors at least 500 m in width should be maintained between these areas.

Table J.1
Palatability of Plant Species for Key Wildlife Indicator Species Based Upon Defined Community Types

Plant Species		Palatabiltity For Key Wildlife Indicator Species															
Common Name	Latin Name	Black Bear			Moose			General Palatability[d]		Ruffed Grouse			Snowshoe Hare		Red-backed Vole		
		Food Use[a]	Food[f]	Percent Frequency[g]	Food Use[a, i]	Percent Weight[e]	Common Forages[j]	Palatability	Tolerance	Food Use[a]	Percent Volume[b]	Percent Volume[c]	Food Use[a]	Food[f]	Food Use[a]	Food Use[k]	Mean Consumption[h]
Shrub Layer																	
balsam fir	*Abies balsamea*				2-3	16.92				3-4				m			
green alder	*Alnus crispa*				1-3, 2		•	Medium	Medium	+			1	m			
river alder	*Alnus tenuifolia*				2-3, 2		•	Medium	Medium	3-4			3-4	m			
Saskatoon	*Amelanchier alnifolia*	1		t	1, 1	0.88	•	Medium	Medium	2	5%	2.5%	1				
Bearberry	*Arctostaphylos uva-ursi*			38				Medium	Medium							•	
white birch	*Betula papyrifera*	3-4			2-3, 2		•	Medium	Medium	1-2		9.2%	2	m			
Dogwood	*Cornus stolonifera*	+			1-2, 1	25.34	•	Medium-High	High	1-2 +		1.6%					
beaked hazelnut	*Corylus cornuta*				1	0.81	•			1-3	4%	1.4%	2	m		•	
Labrador tea	*Ledum groenlandicum*				1	0.04	•										
twin-flower	*Linnaea borealis*						•										
bracted honeysuckle	*Lonicera involucrata*			t			•							u			
white spruce	*Picea glauca*						•	High	Low	1-2			3	m			0.19
black spruce	*Picea mariana*						•					t		m			
balsam poplar	*Populus balsamifera*			5	2	6.85	•	Medium-High	High		1%			m			
aspen	*Populus tremuloides*				3, 3	7.47	•	Medium-High	Medium-High	3-4	35%		2-3	m		•	
pin cherry	*Prunus pensylvanica*	1-4			1 +		•			1-2		10.6%	+				
choke cherry	*Prunus virginiana*	1-4			1 +	0.13	•	Medium	Medium	1-2			+			•	3.1•
currant	*Ribes spp.*			24.4			•										
prickly rose	*Rosa acicularis*			18.5		0.03	•	High	Medium	1 +	5%					•	
wild red rasberry	*Rubus idaeus*		m	28	-	0.04	•	Low-Medium	Medium	1-2 +		8.8%		m		•	
Willow	*Salix spp.*			8.5	2-3, 1	22.64	•	High	High	1-2	31%		2-3	m			
Canada buffalo-berry	*Sheperdia canadensis*	1		40			•	Low	Medium-High		2%					•	
Snowberry	*Symphoricarpos albus*									2			1	u			
Blueberry	*Vaccinium myrtilloides*	3-4	m	43•						1-2 +			3				
bog cranberry	*Vaccinium vitis-idaea*	+	m	43•	+					1			-		-	•	
low-bush cranberry	*Viburnum edule*				2-3		•			1-2		2.0%	3	m & u			

Table J.1 (cont'd)

Plant Species		Palatabiltity For Key Wildlife Indicator Species															
Common Name	Latin Name	Black Bear			Moose			General Palatability[d]		Ruffed Grouse			Snowshoe Hare		Red-backed Vole		
		Food Use[a]	Food[f]	Percent Frequency[g]	Food Use[a, i]	Percent Weight[e]	Common Forages[j]	Palatability	Tolerance	Food Use[a]	Percent Volume[b]	Percent Volume[c*]	Food Use[a]	Food[f]	Food Use[a]	Food Use[k]	Mean Consumption[h]
Forb Layer			m											m			
wild sarsaparilla	*Aralia nudicaulis*																
showy aster	*Aster conspicuus*			3*						+							
lady fern	*Athyrium felix-femina*									1			2				
Bunchberry	*Cornus canadensis*																2.4
shield fern	*Dryopteris carthusiana*									+		1.2%	2				
Fireweed	*Epilobium angustifolium*			3.5	1			Medium	Low								
common horsetail	*Equisetum arvense*	+		50*	2		•										
meadow horsetail	*Equisetum pratense*	+		50*	2		•										
scouring rush	*Equisetum scirpoides*	+		50*	2		•										
woodland horsetail	*Equisetum sylvaticum*	+			2		•										
oak fern	*Gymnocarpium dryopteris*												2				
cream-coloured vetchling	*Lathyrus ochroleucus*			73			•	Medium	Low	+							
stiff club-moss	*Lycopodium annotinum*																
wild lily-of-the-valley	*Maianthemum canadense*									+			1				3.0
tall lungwort	*Mertensia paniculata*																
common pink wintergreen	*Pyrola asarifolia*									+							
Dewberry	*Rubus pubescens*			22						1-2							
Grass Layer			m	89.33*										m			
marsh reed grass	*Calamagrostis canadensis*							Low-Medium	Low								
Sedge	*Carex spp.*	+			2		•	Medium	Medium	2		2.3%		m			
hairy wild rye	*Elymus innovatus*							Low & Medium	Medium								

Footnotes to Table J.1

[a] Martin, A.C., H.S. Zim and A.L. Nelson. 1951. American plants and wildlife: a guide to wildlife food habits:
- = Use to an indeterminate extent; + = 0.5-2 % of diet; 1 = 2-5 % of diet; 2 = 5-10% of diet; 3 = 10-25% of diet;
4 = 25-50% of diet; 5 = 50% or more of diet. Multiple values reflect regional variations in species usage.

[b] Doerr, P.D. 1973. Ruffed grouse ecology in central Alberta - demography, winter feeding activities, and the impact of fire. Doctoral Thesis, University of Wisconsin.

[c] Bump, G, R.W. Darrow, F.C. Edminster and W.F. Crissey. 1947. The ruffed grouse. * includes volumetric percentages to genus level, t = trace.

[d] Hardy BBT Limited 1989. Manual of plant species suitability for reclamation in Alberta - 2nd Edition. Alberta Land Conservation and Reclamation Council Report No. RRTAC 89-4. 436 pp.

[e] Zach, R. and K.R. Mayoh. 1982. The transfer of fallout Cesium-137 from browse to moose part 1: moose food habits.

[f] Chapman, J.A. and G.A. Feldhamer. 1982. Wild mammals of North America: m = major foods in Canada: u = unpalatable.

[g] Holcroft, A. and S. Herrero. 1991. Black bear, *Ursus americanus*, food habits in southwestern Alberta. Canadian Field-Naturalist 105 (3):335-345. Note: genus level.

[h] Vickery, W.L. 1979. Food consumption and preferences in wild populations of *Clethrionomys gapperi* and *Napaeozapus insignis*. Can. J. Zool. 57: 1536-1542.

[i] Beckingham, J.D. and J.H. Archibald. 1996. Field guide to ecosites of northern Alberta. Special Report No. 5, Canadian Forest Service.

[j] Stelfox, J. B. (ed.). 1993. Hoofed mammals of Alberta. Lone Pine Publisher, Edmonton, Alberta.

[k] Green, J.E. 1979. The ecology of five major species of small mammals in the AOSERP study area: a review. Prep. for the Alberta Oil Sands Environmental Research Program by LGL Ltd. AOSERP Report 72. 104 pp:
* = species.

[l] BOVAR Environmental and Axys Environmental Consultants. 1996. Wildlife populations and habitat resources for the Syncrude local study area and the Syncrude/Suncor regional study area. Preferred species in north-eastern Alberta: 1 = most preferred.

Table J.2
Habitat Suitability Index Values For Key Wildlife Indicator Species For Ecosite Phases And Plant Community Types Within The Syncrude Aurora Mine Area.[(A)(B)]

Ecosite	Ecosite Phase	Plant Community Type	HSI (Overall)							
			Cape May Warbler	Great Gray Owl	Ruffed Grouse	Snowshoe Hare	Red-backed Vole	Fisher	Black Bear	Moose
a lichen	a1 jack pine/lichen		0.47	-	0.24	0.23	0.49	0.45	0.67	
		a1.1 jack pine/bearberry/lichen	0.45	0.23	0.24	0.2	0.49	0.39	0.67	0.3
		a1.2 jack pine/blueberry/lichen	0.45	0.2	0.14	0.18	0.38	0.32	0.35	0.25
		a1.3 jack pine/green alder/lichen	0.45	0.23	0.25	0.31	0.41	0.35	0.81	0.3
b blueberry	b1 jack pine-aspen/blueberry		0.24	0.38	0.51	0.53	0.57	0.66	0.76	0.47
		b1.1 jack pine-aspen/blueberry-bearberry	0.22	0.24	0.43	0.53	0.51	0.59	0.88	0.5
		b1.2 jack pine-aspen/blueberry-green alder	0.22	0.19	0.49	0.67	0.69	0.71	0.94	0.5
		b1.3 jack pine-aspen/blueberry-Labrador tea	-	0.29	0.64	0.3	0.47	0.6	0.9	0.33
	b2 aspen (white birch)/blueberry		0.02	-	0.64	0.1	0.31	0.42	0.1	-
		b2.1 aspen (white birch)/blueberry-bearberry	-	-	-	-	-	-	-	-
		b2.2 aspen (white birch)/blueberry-green alder	-	-	-	-	-	-	-	-
		b2.3 aspen (white birch)/blueberry-Labrador tea	-	-	-	-	-	-	-	-
	b3 aspen (white spruce)/blueberry		0.12	-	0.47	0.63	0.65	0.69	0.62	-
		b3.1 aspen-white spruce/blueberry-bearberry	0.12	0.21	0.47	0.63	0.65	0.69	0.62	0.33
		b3.2 aspen-white spruce/blueberry-green alder	0.4	0.37	0.31	0.29	0.35	-	0.62	0.22
		b3.3 aspen-white spruce/blueberry-Labrador tea	0.45	0.25	0.43	0.4	0.66	0.57	0.32	0.31
	b4 white spruce-jack pine/blueberry		0.27	-	0.44	0.7	0.79	0.8	0.8	-
		b4.1 white spruce-jack pine/blueberry-bearberry	0.25	0.17	0.44	0.7	0.79	0.79	0.8	0.36
		b4.2 white spruce-jack pine/blueberry-green alder	0.25	0.17	0.36	0.68	0.76	0.83	0.54	0.41
c Labrador Tea-mesic	c1 jack pine-black spruce/Labrador tea-mesic		0.47	-	0.26	0.38	0.57	0.45	0.6	-
		c1.1 jack pine-black spruce/Labrador tea/feather moss	0.45	0.25	0.26	0.38	0.61	0.46	0.6	0.3
		c1.2 jack pine-black spruce/green alder/feather moss	0.45	0.25	0.26	0.38	0.61	0.46	0.6	0.3
		c1.3 jack pine-black spruce/feather moss	0.45	0.25	0.26	0.38	0.61	0.46	0.6	0.3

Table J.2 (cont'd)

Ecosite	Ecosite Phase	Plant Community Type	HSI (Overall)							
			Cape May Warbler	Great Gray Owl	Ruffed Grouse	Snowshoe Hare	Red-backed Vole	Fisher	Black Bear	Moose
d low-bush cranberry	d1 aspen/low-bush cranberry		0.02	-	0.7	0.91	0.76	0.68	0.96	-
		d1.1 aspen/Canada buffalo-berry	0.03	0.21	0.73	0.78	0.77	0.58	0.92	0.56
		d1.2 aspen/saskatoon-pin cherry	0.02	0.29	0.87	0.91	0.83	0.68	0.98	0.73
		d1.3 aspen/beaked hazelnut	-	-	-	-	-	-	-	-
		d1.4 aspen/green alder	0.02	0.25	0.8	1	0.79	0.72	0.98	0.73
		d1.5 aspen/low-bush cranberry	0.02	0.27	0.67	0.68	0.9	0.73	0.94	0.49
		d1.6 aspen/rose	0.02	0.21	0.64	0.78	0.74	0.57	0.92	0.59
		d1.7 aspen/beaked willow	0.02	0.35	0.22	0.47	0.29	0.24	0.53	0.46
		d1.8 aspen/forb	-	-	-	-	-	-	-	-
		d1.9 aspen/balsam fir	0.02	0.23	0.7	0.91	0.76	0.64	0.96	0.7
	d2 aspen-white spruce/low-bush cranberry		0.11	-	0.5	0.68	0.57	0.5	0.6	-
		d2.1 aspen-white spruce/Canada buffalo-berry	0.11	0.47	0.53	0.51	0.67	0.43	0.88	0.41
		d2.2 aspen-white spruce/beaked hazelnut	0.11	0.21	0.5	0.68	0.57	0.44	0.6	0.44
		d2.3 aspen-white spruce/green alder	0.05	0.25	0.47	0.53	0.47	0.43	0.58	0.5
		d2.4 aspen-white spruce/low-bush cranberry	-	-	-	-	-	-	-	-
		d2.5 aspen-white spruce/rose	0.11	0.21	0.46	0.61	0.54	0.4	0.6	0.44
		d2.6 aspen-white spruce/beaked willow	-	-	-	-	-	-	-	-
		d2.7 aspen-white spruce/forb	-	-	-	-	-	-	-	-
		d2.8 aspen-white spruce/balsam fir/feather moss	-	-	-	-	-	-	-	-
		d2.9 aspen-white spruce/feather moss	0.11	0.21	0.5	0.68	0.57	0.44	0.6	0.44
	d3 white spruce/low-bush cranberry		0.85	-	0.31	0.46	0.4	0.45	0.74	-
		d3.1 white spruce/Canada buffalo-berry	-	-	-	-	-	-	-	-
		d3.2 white spruce/green alder	0.85	0.22	0.4	0.61	0.57	0.46	0.88	0.6
		d3.3 white spruce/low-bush cranberry	0.65	0.38	0.38	0.31	0.53	0.61	0.61	0.58
		d3.4 white spruce/balsam fir/feather moss	-	-	-	-	-	-	-	-
		d3.5 white spruce/feather moss	0.75	0.09	0.12	0.54	0.79	0.5	0.34	0.19

Table J.2 (cont'd)

Ecosite	Ecosite Phase	Plant Community Type	HSI (Overall)							
			Cape May Warbler	Great Gray Owl	Ruffed Grouse	Snowshoe Hare	Red-backed Vole	Fisher	Black Bear	Moose
e dogwood	e3 white spruce/dogwood		0.65	0.41	0.33	0.22	0.48	0.7	0.41	0.52
		e3.1 white spruce/dogwood/fern	0.65	0.32	0.33	0.22	0.57	0.69	0.55	0.52
		e3.2 white spruce/green alder-river alder/fern	0.65	0.41	0.33	0.22	0.57	0.69	0.55	0.52
		e3.3 white spruce/balsam fir/fern	-	-	-	-	-	-	-	-
		e3.4 white spruce/fern/feather moss	-	-	-	-	-	-	-	-
g Labrador tea-subhygric	g1 black spruce-jack pine/Labrador tea-subhygric		0.38	0.11	0.09	0.81	0.45	0.39	0.48	0.19
		g1.1 black spruce-jack pine/Labrador tea/feather moss	0.41	0.08	0.09	0.81	0.35	0.5	0.58	0.19
		g1.2 black spruce-jack pine/feather moss	0.38	0.11	0.09	0.81	0.47	0.5	0.62	0.19
h Labrador tea/horsetail	h1 white spruce-black spruce/Labrador tea/horsetail		0.38	-	0.11	0.66	0.48	0.48	0.31	-
		h1.1 white spruce-black spruce/Labrador tea/horsetail	0.18	0.08	0.06	0.64	0.38	0.37	0.14	0.19
		h1.2 white spruce-black spruce/ Labrador tea/feather moss	0.38	0.12	0.14	0.66	0.4	0.41	0.59	0.23
i bog	i1 treed bog i2 shrubby bog		0.53	-	0.1	0.59	0.45	0.39	0.3	-
		i1.1 black spruce/Labrador tea/cloudberry/peat moss	0.53	0.11	0.1	0.48	0.45	0.33	0.44	0.19
			0.53	0.15	0.1	0.59	0.51	0.39	0.16	0.19
		i2.1 black spruce-Labrador tea/cloudberry/peat moss	0.53	0.15	0.22	0.59	0.65	0.43	0.16	0.19
j poor fen	j1 treed poor fen j2 shrubby poor fen		0.53	-	0.22	0.74	0.56	0.49	0.32	0.37
		j1.1 black spruce-tamarack-dwarf birch-sedge/peat moss	0.53	0.16	0.22	0.74	0.65	0.46	0.32	0.37
			0.06	-	0.06	0.89	0.38	0.53	0.14	0.18
		j2.1 black spruce-tamarack-dwarf birch/sedge/peat moss	0.15	0.12	0.06	0.89	0.38	0.49	0.14	0.18

Table J.2 (cont'd)

Ecosite	Ecosite Phase	Plant Community Type	HSI (Overall)							
			Cape May Warbler	Great Gray Owl	Ruffed Grouse	Snowshoe Hare	Red-backed Vole	Fisher	Black Bear	Moose
k rich fen	k1 treed rich fen k2 shrubby rich fen k3 graminoid rich fen		0.53	-	0.1	0.59	0.47	0.39	0.16	-
		k1.1 tamarack/dwarf birch/sedge/golden moss	0.53	0.15	0.1	0.59	0.57	0.39	0.16	0.19
			0.05	-	0.18	0.72	0.38	0.42	0.14	-
		k2.1 dwarf birch/sedge/golden moss	0.06	0.14	0.08	0.64	0.42	0.34	0.18	0.17
		k2.2 willow/sedge/brown moss	0.02	0.17	0.31	0.67	0.3	0.35	0.11	0.59
		k2.3 willow/marsh reed grass	-	-	-	-	-	-	-	-
			0.03	0.72	0.03	0.04	0.05	0.11	0	0.17
		k3.1 sedge fen	-	-	-	-	-	-	-	-
		k3.2 marsh reed grass fen	-	-	-	-	-	-	-	-
l marsh	l1 marsh		0.53	0.11	0.10	0.48	0.45	0.33	0.44	0.19
		l1.1 cattail marsh	0.53	0.11	0.10	0.48	0.45	0.33	0.44	0.19
		l1.2 reed grass marsh	-	-	-	-	-	-	-	-
		l1.3 bulrush marsh	-	-	-	-	-	-	-	-

(A) Beckingham and Archibald 1996. Field Guide to Ecosites of Northern Alberta.
(B) HSI values were not calculated for great grey owl and moose for ecosite phases because these involved buffer calculations.

J4.2 BLACK BEAR

J4.2.1 Food and Cover Requirements

For much of the year, habitats selected by black bears for their food producing abilities (Table J.1) also provide adequate escape cover. The highest quality habitat occurs in forested communities with the following characteristics: a dense berry-producing shrub stratum; dense tree or shrub cover for predator avoidance and bedding; and, trees suitable for climbing to escape predators. Reclamation habitats important to black bears in the oil sands area include vegetation communities representative of the following ecosite phases (Table J.2):

- High Suitability Habitats - jack pine-aspen/blueberry (b1); aspen/low-bush cranberry (d1) and, to a lesser degree, aspen-white spruce/low-bush cranberry (d2); white spruce/low-bush cranberry (d3); and white spruce-jack pine/blueberry (b4) ecosite phases.

- Moderate Suitability Habitats - jack pine/lichen (a1); aspen-white spruce/blueberry (b3); jack pine-black spruce/Labrador tea-mesic (c1); aspen-white spruce low-bush cranberry (d2); white spruce/dogwood (e3); black spruce-jack pine/Labrador tea-subhygric (g1); and, to a lesser degree, white spruce/low-bush cranberry (d3).

J4.2.2 Landscape Component

Habitat selection varies seasonally based on food availability. Habitat interspersion is therefore an important factor determining habitat quality and the following factors should be considered in the development of reclaimed landscapes for black bears:

- During the early spring following denning, black bears select open areas where they feed on newly emergent vegetation. The extent to which open areas are utilized decreases with increasing distance from cover. Reclaimed forest communities with high cover values should be developed within 200 m of open areas, such as successional habitats or bog ecosites that serve as early spring feeding areas for black bears.

- For denning habit, reclaimed forest communities should be developed on steep north and east-facing slopes.

J4.3 SNOWSHOE HARE

J4.3.1 Food and Cover Requirements

The snowshoe hare is common and widely distributed resident of the boreal forest, inhabiting forests, swamps and riverside thickets. Although the apparent overstory preferences of snowshoe hare can be highly variable from region to region, it is widely accepted that all habitats supporting hares contain a low, dense brushy (deciduous or coniferous) understory. Within the oil sands area vegetation communities representative of the following reclamation ecosite phases provide suitable habitat for the snowshoe hare:

- High Suitability Habitats: white spruce-jack pine/blueberry (b4); aspen/low-bush cranberry (d1); aspen-white spruce/low-bush cranberry (d2); and black spruce-jack pine/Labrador tea-subhygric (g1) ecosite phases.
- Moderate Suitability Habitats: jack pine-aspen/blueberry (b1); aspen-white spruce/blueberry (b3); aspen/low-bush cranberry (d1); aspen-white spruce/low-bush cranberry (d2); and white spruce-black spruce/Labrador tea/horsetail (h1).

J4.3.2 Landscape Component

In general, habitat quality increases with increased vegetation community interspersion and the following factor should be considered when developing reclaimed areas for the snowshoe hare:

- Reclaimed landscapes should include a patchy habitat mosaic including dense thickets for winter use and more open summer range.

J4.4 RED SQUIRREL

J4.4.1 Food and Cover Requirements

The red squirrel is a resident of mature, spruce dominated forests in montane and boreal regions of North America. Coniferous trees provide escape and thermal cover. However, food appears to be the single most important factor influencing the distribution of the red squirrel. The seeds of white and black spruce are the most important dietary item and influence reproduction and territory size. White spruce seeds are favoured over black spruce seeds. Although detailed habitat modelling has not been conducted, it is believed that mature, reclaimed forest communities representative of the following ecosite phases will provide habitat for the red squirrel:

- High Suitability Habitats - jack pine/lichen (a1) white spruce-jack pine/ blueberry (b4); white spruce/low-bush cranberry (d3); white spruce/dogwood

(e3); black spruce-jack pine/Labrador tea-subhygric (g1); and white spruce-black spruce/Labrador tea/horsetail (h1).

- Moderate Suitability Habitats - aspen-white spruce/blueberry (b3); jack pine-black spruce/Labrador tea-mesic (c1); aspen-white spruce/low-bush cranberry (d2); and balsam poplar-white spruce/dogwood (e2).

J4.4.2 Landscape Requirements

The following factor should be considered in the development of reclaimed forests for the red squirrel:

- Currently, there are no estimates of required block sizes for red squirrels. However, estimates of territory size range from 0.2 to 4 ha. Habitat blocks developed for red squirrel should therefore be a minimum of 4 ha and preferably much larger, probably an order of magnitude larger.

J4.5 RUFFED GROUSE

J4.5.1 Food and Cover Requirements

The ruffed grouse is a non-migratory, widely distributed species, occurring in a broad band of deciduous and mixed deciduous-coniferous forest habitats across North America. The overriding factor in habitat selection is the presence of a substantial deciduous tree component, particularly aspen and birch, in the tree canopy. Vegetation communities representative of the following ecosite phases have been ranked as important habitats for ruffed grouse in the oil sands area:

- High Suitability Habitats: aspen/low-bush cranberry (d1) ecosite phase.

- Moderate Suitability Habitats: jack pine-aspen/blueberry (b1); aspen (white spruce) blueberry (b2); aspen-white spruce/blueberry (b3); white spruce-jack pine/blueberry (b4); aspen/low-bush cranberry (d1); aspen-white spruce/low-bush cranberry (d2); and balsam poplar-aspen/dogwood (e1) and balsam poplar-white spruce dogwood (e2) ecosite phases.

J4.5.2 Landscape and Special Habitat Requirements

The following factors should be considered in the development of reclaimed forests for ruffed grouse:

- Initial stem densities of < 14 800/ha should be established in habitat areas developed for ruffed grouse.

- Forests developed for ruffed grouse should include small forest openings 0.1 to 0.5 ha in size to provide brood rearing habitat.

- Drumming logs are important for territorial displays by male grouse, and can be added to moderate aged successional habitats to improve habitat quality.

J4.6 FISHER

J4.6.1 Food and Cover Requirements

The food and cover requirements of the fisher are provided by mature to old forest with a strong coniferous component and dense canopy closures. Within the oil sands area, suitable habitats for the fisher are provided in vegetation communities representative of the following ecosite phases:

- High Suitability Habitats: aspen-white spruce/blueberry (b3); white spruce-jack pine/blueberry (b4); and white spruce/low-bush cranberry (d3) ecosite phases.

- Moderate Suitability Habitats: jack pine-aspen/blueberry (b1); aspen-white spruce/blueberry (b3); jack pine-black spruce/Labrador tea-mesic (c1); aspen/low-bush cranberry (d1); aspen-white spruce/low-bush cranberry (d2); white spruce/ low-bush cranberry (d3); and black spruce-jack pine/Labrador tea-subhygric (g1).

J4.7 GREAT GREY OWL

J4.7.1 Food and Cover Requirements

Great grey owl breeding habitat consists of extensive forest interspersed with sphagnum bogs, muskeg and other open spaces. Nesting commonly occurs in stands of mature poplar adjacent to muskegs. Islands of poplar amid stands of spruce or pine are common nesting locations, as are groves of marginal strips of often-stunted tamaracks in wetter sites. Great grey owls primarily prey on small mammals, especially rodents. Meadow voles dominate the diet of the great grey owl over most of the owl's range, particularly in the northern boreal forest. Because of its dependence on meadow voles, habitat utilization of great grey owls is closely linked to that of the meadow vole. Typically meadow voles occur in wet areas dominated by dense, grassy vegetation.

Within the oil sands region, great grey owls are largely dependent on one vegetation community representative of the graminoid rich fen ecosite phase. Unfortunately, this habitat cannot be developed on reclaimed landscapes. Nonetheless, the habitat requirements of the great grey owl can be incorporated in the development of reclamation landscapes adjacent to undisturbed areas dominated by this plant community (see below). Only five vegetation communities with moderate habitat quality for great grey owls can be developed on reclaimed landscapes (Table J.2). These communities are representative of the aspen-white spruce/blueberry (b3); aspen/low-bush cranberry (d1); aspen-white spruce/low-bush cranberry (d2); white spruce/low-bush cranberry (d3); and white spruce/dogwood (e3) ecosite phases.

J4.7.2 Landscape Component

Habitat interspersion is an important aspect of habitat selection and the following factors should be incorporated into the development of reclaimed landscapes for great grey owls:

- Typically this species is reliant on open grassy areas for foraging, and mature forested areas for nesting. These two habitat conditions must therefore occur to adjacent to one another to create suitable nesting areas. Ideally mature forest communities, with an aspen component, should be established within 500 m of graminoid rich fen ecosite phases left in undeveloped area adjacent to reclaimed landscapes.
- The habitat suitability of foraging areas could be increased by establishing perches in foraging areas. This could be done by planting individual or small isolated patches of trees, or by placing poles in graminoid rich fen ecosite phases.
- Nest site availability could be increased by establishing artificial nest sites (nest baskets or nest poles) in forested areas located within 500 m of foraging habitat.

J4.8 CAPE MAY WARBLER

J4.8.1 Food and Cover Requirements

The Cape May warbler is a neotropical migrant breeding in the boreal forest of North America. Cape May warblers breed in mature white spruce stands within coniferous and mixed wood forests, preferring open stands and stand edges. Within the oil sands area, vegetation communities representative of the following ecosite phases will provide breeding habitat for the Cape May warbler:

- High Suitability Habitat: white spruce/low-bush cranberry (d3) and white spruce-jack pine blueberry (b4) ecosite phase.
- Moderate Suitability Habitat: jack pine/lichen (a1); jack pine-aspen/blueberry (b1); aspen-white spruce/blueberry (b3); jack pine-black spruce/Labrador tea-mesic (c1); white spruce/low-bush cranberry (d3) ecosite phase; white spruce/dogwood (e3); and black spruce-jack pine/Labrador tea-subhygric (g1).

J4.8.2 Landscape Component

The following factors should also be considered in the development of re-constructed landscapes for Cape May warblers:

- Edge area should be maximized in vegetation communities planted for Cape May warblers.

- Males select tall conifers that rise above the rest of the canopy for singing perches. This condition should be mimicked in reclaimed forests established for Cape May warblers. This could possibly be accomplished by planting low densities of white spruce (25-50 m spacing) in suitable habitat areas and allowing the rest of the forest to develop around these trees.

J4.9 OVENBIRD

J4.9.1 Food and Cover Requirements

The food and cover requirements of the oven bird are met in mature, closed deciduous and mixed wood forests with little ground cover. Mature, reclaimed vegetation communities representative of the following ecosite phases will most likely provide breeding habitat for ovenbirds: jack pine-aspen/blueberry (b1); aspen (white birch)/blueberry (b2); and aspen-white spruce/blueberry (b3).

J4.9.2 Landscape Component

The following factor should be incorporated into the development of reclaimed landscapes for ovenbirds:

- Habitat blocks that are a minimum of 4 ha in size are required before breeding ovenbirds will occupy an area.

J4.10 WARBLING VIREO

J4.10.1 Food and Cover Requirement

Warbling vireos are associated with old (60+ years) deciduous and mixed wood forests with an open canopy and dense shrub understory. Mature forest communities representative of the following ecosite phases will provide breeding habitat for the warbling vireo: jack pine-aspen/blueberry (b1); aspen (white birch)/blueberry (b2); aspen-white spruce/blueberry (b3); aspen/low-bush cranberry (d1); and aspen-white spruce/low-bush cranberry (d2).

J4.10.2 Landscape Component

Habitat interspersion can improve habitat quality and the following factor should be considered in the development of reclaimed landscapes for the warbling vireo:

- Early successional and other shrub dominated communities should be established adjacent to open, mature deciduous dominated forests to increase the amount of foraging habitat available for warbling vireos.

J4.11 RED-BACKED VOLE

J4.11.1 Food and Cover Requirements

Although the red-backed vole occupies a wide variety of plant communities, it is generally most abundant in moist, mature forests with relatively dense shrub canopies and abundant litter, moss and deadfall. Clearings and other unforested habitats are generally avoided unless an abundance of protective ground litter and shrub cover is present. Within the oil sands region, reclaimed forest communities representative of the following ecosite phases will provide habitat for the red-backed vole:

- High Suitability Habitats - jack pine-aspen/blueberry (b1); aspen-white spruce/ blueberry (b3); white spruce-jack pine/blueberry (b4); and aspen/low-bush cranberry (d1) ecosite phases.
- Moderate Suitability Habitats - jack pine/lichen (a1); jack pine-aspen/blueberry (b1); aspen-white spruce/blueberry (b3); jack pine-black spruce/Labrador tea-mesic (c1); aspen-white spruce/low-bush cranberry (d2); white spruce/dogwood (e3); and black spruce-jack pine/Labrador tea- subhygric (g1).

J4.12 DEER MOUSE

J4.12.1 Food and Cover Requirements

The deer mouse is a widely distributed species, which shows few restrictions in habitat use. Preferred habitats include deciduous, mixed and coniferous forests and shrublands with dense ground and litter cover. Early successional habitats are also occupied by the species. A two-year study conducted in the region revealed that deer mice preferred balsam poplar and mixed wood forests and early successional habitats. In contrast, willow-birch and tamarack habitats were avoided and jack pine and black spruce forests received marginal use. Some differences in habitat use were, however, noted between the two years of the study. Based on the results of this study, habitat preference in the oil sands area will probably be shown towards reclaimed vegetation communities representative of the following ecosite phases:

- High Suitability Habitat: aspen (white birch)/blueberry (b2); aspen-white spruce/ blueberry (b3); aspen/low-bush cranberry (d1); aspen-white spruce/low-bush cranberry (d2); balsam poplar-aspen/dogwood (e1); balsam poplar-white spruce/ dogwood (e2); white spruce/dogwood (e3); and white spruce-black spruce/Labrador tea/horsetail (h1).
- Moderate Suitability Habitat: jack pine/lichen (a1); jack pine-aspen/blueberry (b1); white spruce-jack pine/blueberry (b4); jack pine-black spruce/Labrador tea-mesic (c1); white spruce/low-bush cranberry (d3); and black spruce-jack pine/ Labrador tea-subhygric (g1).

J5. LITERATURE CITED

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